Universiteit Leiden

ICT in Business

Harnessing the power of data for government real estate

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MASTER'S THESIS

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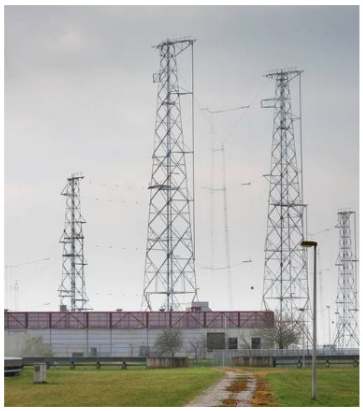


Acknowledgement

What an adventure it has been. For years I wanted to earn a Master's degree, for my personal development. In September 2016 I took the plunge and started the Master ICT in Business and the Public Sector. My aim was to do this in four years, twice the period it took full-time students.

When I started, my three year old daughter went to daycare two mornings in the week, and my son was only six months old. I was working at the fire department of The Hague and living in Nootdorp. Now, when I write this foreword after finishing the first version of this report, it is five years later. My children are both at school, I moved to The Hague and I work for the CGREA. And the four years I aimed for became five and some months because of, mainly, COVID-19. A lot can happen in life while studying at the university.

These past years flew by in what feels like an instant. In the first years I went to classes one or two times a week after work. I learned a lot, met like-minded people and enjoyed the thrill of finishing a course. I had a difficult time working on my thesis during the first year of the COVID crisis, with children at home, working at home and moving to a new house. However, the past year I picked it up and I am proud of the result that is culminated in this document.

I could absolutely not have done it alone. My thanks go first and foremost to my wife. She made it possible for me to go to college while she was at home with two small children. And she suffered me behind te laptop for many evenings at home. She only just started her own adventure, earn a bachelor degree, and I can only hope to repay her in kind.

Thanks also go to my two supervisors, Peter and Mitra. Valuable feedback helped me keep track and not lose focus. And of course my colleagues. They endured me continuously ranting about the things I found out during my studies and my thesis research project. They took the time for interviews and feedback. And, in the case of former colleagues, gain access to the National Police and the Municipality of The Hague.

With this project, the adventure has come to an end. For now. It is time to enjoy the evenings without ever-present knowledge that I should really be working on my thesis. It was an unforgettable experience, but it is also great to reach the end.

I hope you enjoy reading this report as much as I have (most of the time) enjoyed writing it.

Wouter van Steenbergen

Abstract

Governments own large amounts of real estate. Among these are numerous offices. The real estate portfolio is vital for the organisational goals of governments. Because of this, strategic decisions are made continuously: when to buy, sell, transform or build real estate? Information is essential for these decisions.

Meanwhile, big data is a technology also eyed by governments. Buildings use many building based systems to control temperature, maintain access and security and provide services. These systems generate data, which could be analysed for decision making.

This project analyses the strategic decisions made in public real estate in The Netherlands and the use of big data in these decisions. Can data from building based systems contribute to this decision making? Improved decision making can have a significant impact, because the costs involved in real estate are significant.

The research aims to answer the following question: to what extent can building based big data contribute to strategic decision making in Dutch public real estate management?

The methodology used is the structured-pragmatic-situational approach (Pan & Tan, 2011), a case study where the Dutch Central Government Real Estate Agency is the main focus. The National Police and the Municipality of The Hague are also used as reference.

Based on a literature analysis followed by structured qualitative research using interviews with various decision makers, the challenges, information required and data available were reviewed.

The literature was analysed using three themes: Big data, public real estate management and building based data:

Big data is defined by having at least three characteristics: volume (large amount), velocity (near real-time) and variety (various types and sources). Big data has both technological and organisational requirements. Governments explore big data to, among others, improve public decision making. However, many initiatives have trouble rising beyond the pilot-stage.

Public real estate management is comparable to corporate real estate management. Both involve strategic decisions surrounding company real-estate, an important asset for company goals. Continuous management is necessary, including when to buy, sell, build or transform real estate. Public real estate management is different because it has other stakeholders. For commercial companies, shareholders are most important because the main goals are economical. For public organisations, political goals and societal goals are an important influence. Public real estate management as a strategic decision making process has multiple challenges, related to strategy, portfolio, finance and technology.

Building based data is not only used for the primary purpose: controlling building based systems to control the climate, the energy and security. The data is also useable to generate insights based on the information it provides. There are established sources for data, such as the building automation systems and utility meters. And emerging sources, such as access control systems and security systems. Possible usages for this data can be found in KPI's for real estate that are defined in literature. These KPI's could be measured using the data from building systems.

Based on the literature findings, interviews were held with decision makers that are responsible for strategic decisions in public real estate. The challenges and characteristics of public real estate management were verified in open questions. After that, the information requirements of the decisions being made were explored.

The interviews were analysed in a structured way using selective coding. Next to that, key documents from the case organisation were also studied. All information was used to answer the research question, while continuously checking alignment between the research data that was gathered, the literature findings and the emerging theory.

In both the primary case organisation as the reference organisations, strategic decisions were confirmed to require data. Data availability and accuracy is, however, an concurrent issue. And one important piece of information for strategic decisions is missed: insight in continuous building occupancy. This is information that can not be gained with current methods, but could very well be generated using building based data. This leads to the conclusion that big data initiatives for public real estate can provide valuable new insights to use in this process.

Contents

Chapter 1

Introduction

1.1 Case background

1.1.1 Dutch government real estate

Source: rijksvastgoedbedrijf.nl

Figure 1.1: Binnenhof, example of Dutch government real estate

The Dutch Central Government Real Estate Agency (CGREA) is the organisation that manages real estate owned by the state. The portfolio contains prisons, palaces, courthouses, defence installations and office buildings. In total, 12 million square metres of gross floor space (Central Government Real Estate Agency, 2017). The CGREA is tasked with building, transforming, maintaining, selling and buying government real estate: the management of the Dutch central government real estate portfolio. This is real estate in the entire Kingdom including various Caribbean territories.

The CGREA is a government agency that is part of the Dutch Ministry of the Interior and Kingdom Relations. It was founded only recently, on 1 January 2016. Multiple government organisations that managed government real estate before that date merged into the new organisation. The largest ones being the former Government Buildings Agency and the Defence Real Estate Agency. Not all central government real estate is managed by the CGREA. The National Police real estate, foreign embassies and civil infrastructure (highways, tunnels and waterways) are not part of the CGREA real estate portfolio.

The CGREA has to manage the office portfolio as efficient as possible. The portfolio also has to support the government processes and goals, such as sustainability and accountability. This requires a large organisation: more than 2000 people work at the CGREA and the yearly turnover is more than one billion.

Source: omroepwest.nl

Figure 1.2: The Hague City Hall

1.1.2 Municipality of The Hague

The city of The Hague is the third largest municipality in The Netherlands, after Amsterdam and Rotterdam. It owns around a billion Euro worth of real estate. Typical municipal real estate consists of offices, including the city hall, public pools, sports centres, cultural buildings, neighbourhood centres and grounds for development (Gemeente Den Haag, 2021). Municipalities also own historical buildings, such as windmills and churches.

The municipality has its own organisation to “develop, build, maintain en care for the municipal real estate” (Gemeente Den Haag, 2021). The organisation is called the Central Real Estate Organisation The

Hague (CVDH). However many departments within the municipal organisation have a large responsibility for their own section of the real estate portfolio. The CVDH has an advisory role, but that is expected to change in the near future. Because of the fragmented responsibilities, there is not a single real estate strategy for the municipality. Every department has its own responsibility and therefore its own strategy.

1.1.3 National Police

The National Police is the second-largest public real estate owner in The Netherlands, following the CGREA. In 2013, the National Police was formed. Before that, the police in The Netherlands was organised in multiple separate regional organisations. The National Police consists of ten regional units and four country-wide units. Corporate services, IT and housing for example, are provided by the Police Service Centre (PDC).

source: www.tweesnoekenarchitectuur.nl

Figure 1.3: Police station

In 2015, the real estate portfolio of the National Police enveloped over a 1,000 buildings: offices, dispatch centres, service centres, detainment complexes, airport services and data centres (Algemene Rekenkamer, 2015). The PDC is responsible for management of this portfolio. It also managed strategic decisions about buying or divesting real estate. This is done in cooperation with the various regional and country-wide units.

One of the primary targets of the National Police is raising efficiency and thereby reduce costs. For the real estate portfolio, the goal is to structurally reduce costs by 76,5 million Euro, as stated by in the report by the Court of Audit (Algemene Rekenkamer, 2015).

As became clear in the interviews held for this project, the cost reduction has not been met. The police organisation has evolved and has been given other targets. Real estate has to be able to accommodate the targets. For that reason, the strategy is expected to change in the near future.

1.2 Research background

Public real estate has significance for all government organisations. It is necessary to reach the organisational goals. But it is also expensive and requires effort to maintain. For this reason governments have formed real estate organisations: for example the CGREA, CVDH and the PDC. These organisations manage the real estate portfolio on all levels.

The strategic management of these portfolios envelops the decisions to buy, sell ("divest"), build or transform real estate. Each of these decisions have significant financial impact. The transformation (renovation) of the parliamentary complex, Binnenhof, alone costs over 718 million Euro(Tweede Kamer der Staten-Generaal, 2021).

The strategic decision making process for real estate requires information. At the moment, that comes from static sources, for example building statistics: size, condition, location. More information can help support the decision makers in making these decisions.

At the same time, buildings contain many building based systems. These are for controlling the climate, access and security and energy, among others. These systems for their primary purposes use data. With the rising of big data initiatives, the real estate organisations are beginning to look at this data for different purposes. One of these purposes is creating insights to support decision making.

The building portfolios, however, are large and the data generated substantial. Choices have to be made what data to focus on first. But it is as of yet unknown what data can best be used in the decision making process.

1.3 Significance of the study

1.3.1 Research gap and contribution

As said, data analysis is a current topic in a lot of sectors, also in real estate. A search for "data analysis in public real estate management" on Google Scholar[1] yields no research on the topic proposed for this project. Most research is in the field of commercial property real estate: selling private homes etcetera.

Ullah, Sepasgozar, and Wang (2018) state that "contrary to its industrial counterparts, almost a third of the global real estate industry, worth $11 trillion, is managed on spreadsheets; innovative information technology (IT) tools are missing in action.". This, while from a corporate perspective offices along with salaries and technology are the largest expenses (Taylor, 2013). This means that there is in theory a lot of potential in using data analytics to improve real estate management. .

This research is also relevant for the emergence of so-called smart buildings. There are various definitions, but a lot of time a smart building is considered a building that gathers information with a lot of separately added Internet of Things (IoT) sensors (Dong, Prakash, Feng, & O'Neill, 2019). A search on Google Scholar for "IoT building data strategy" yields results for a lot of practical uses for the data. This means even more data will be available in the future, further requiring real estate owners to be able to fully utilize this data. Most use cases however, are based on commercial real estate. An beside that, adding sensors in a real estate portfolio the size that governments own is costly and complex. Using data from systems already present in most of these buildings is therefore an attractive alternative.

All in all, building based data seems to be a valuable asset for real estate management, as is the case in other sectors. The possibility to use this data seems hardly a question. The overview of research on this topic by Burak Gunay, Shen, and Newsham (2019) for example shows that many research is conducted on the usage of data for real estate. However, it is unclear whether objective data also works for public real estate management where political influence is also present and financial gain is not the primary goal (van der Schaaf, 2002). And with all the data available, what data will be most useful? No research is as of yet available that aims to answer the question what data will be most useful for processes in public real estate.

The contributions this project brings to the research are:

- Insight in the current challenges for strategic public real estate management. Organisational demand of real estate varies over time, and with it the challenges in strategic real estate management. This research combines various challenges defined in literature and verifies the occurrence in the current time.
- Usability of building based data in public real estate management processes. There are multiple scenarios for big data in real estate, but no research is as of yet available on the usability for the strategic management process.
- Answer to the question what insight is needed most in decisions, so which data could be prioritized. This can help focus future research on what big data scenarios to assess.

1.3.2 Research purpose

The purpose of this research is to better understand the effectiveness of big data in strategic public real estate decisions. Various big data initiatives have been deployed within the CGREA. This is not unique for this organisation. As became clear in the interviews held for this research, other government real estate owners have started similar initiatives. The real estate portfolios involved are very large and varied. Data gathering and analysis requires effort and money, so focus is necessary. By looking at the information required and the data that is available, choices must be made.

This research aims to provide the needed focus. As described in the research gap, the availability of the data is not the primary question. The question is what data is primarily required. What data can provide the most valuable insights for the decision makers in the strategic process? And especially: what insights can be generated that are not available in the process currently?

By answering the research question, the project also aims to contribute to the scientific gap described above.

[1] `https://scholar.google.com`

1.4 Hypothesis and research question

Government office buildings contain a lot of building based systems for security, climate control, energy monitoring, etcetera. For their respective primary purpose, these systems generate data. The characteristics of this data are similar to big data.

Big data can be used to provide information, insight, in decision making processes. This insight can be used to make decisions which lead to actions.

In strategic real estate management, decisions are made on a regular basis. In these decisions, information is used, but more information is beneficial to the process.

Considering the above, building data, fitting the definition of big data, could be able to provide information for decisions in the strategic processes in public real estate management.

The above leads to the following hypothesis which is the basis for the research question:

Data from building systems can be defined as big data and therefore can be used to provide information that is not currently available and can be used for decision making in strategic public real estate management processes.

The research will aim to answer the following question to test this hypothesis:

To what extent can building based big data contribute to strategic decision making in Dutch public real estate management?

Based on the research question, a number of sub-questions are defined:

SQ1: What is the difference between public real estate management and commercial real estate management?

SQ2: What is the definition of big data and is this applicable to building based data?

SQ3: What challenges are found for decision making in strategic real estate management?

SQ4: What information is required for these decisions?

SQ5: What building data is available?

SQ6: Can building data provide the required information?

SQ7: Can this data be used in public real estate management?

This research project follows a structured method to perform a case analysis. This method also proposes a full outline for the report which was adopted for this report.

After this chapter, that contained the introduction and the research questions, Chapter 2 gives an overview of findings in existing scientific literature related to the research project. Chapter 3 explains the research methodology and the justification for this methodology. After that, a systematic description of the project and the steps taken in the process is given. Both the process and the data gathered in this process are described. Chapter 4 contains the description of the findings and results, by sub-questions, based on analysis of literature and gathered data. The final chapter contains the conclusion, discussion and topics for future research.

Chapter 2

Literature review

The goal of this chapter is provide insight in scientific research that is relevant to this research project. The goal of this literature review is to set a theoretic basis ("lens") on which the other steps of the project are based.

Based on the sub-questions from Chapter 1, four topics where derived in which relevant literature was searched. The complete method of selection and search is described in Chapter 3.

The four topics are:

1. Big data in the public sector - from sub-questions 2 and 7
2. Difference between commercial and public real estate management - from sub-questions 1 and 3
3. Public real estate strategy - from sub-questions 3, 4 and 7
4. Building based data - from sub-questions 2, 4, 5 and 6

The topics above are reflected in the three sections below, where topics 2 and 3 are both combined in Section 2.2. Each section is concluded by giving an overview of the research questions, the relevant findings in the literature and the role of this project in filling identified gaps.

2.1 Big data in the public sector

2.1.1 Big data

In the last decades, the amount of data in a variety of fields has been increasing enormously. It is expected to double every two years (Chen, Mao, & Liu, 2014). The majority of data available today has been generated in the last few years (Tabesh, Mousavidin, & Hasani, 2019). The availability of this data, combined with the computing power currently available to analyse these vast amounts has created a lot of interest in both research and industry (Klievink, Romijn, Cunningham, & de Bruijn, 2017; Chen et al., 2014). The ability to gather and analyse all this data has urged many organisations to invest time, money and energy in creating insights from this data in a way that Tabesh et al. (2019) compare to a gold rush or S. Sun, Cegielski, Jia, and Hall (2018) describe as "the new oil". The concept is called Big Data. A driving goal behind this so-called gold rush is for organisations to use this data to make decisions based on evidence from this data, by generating meaningful insights from the available data (Konanahalli, Marinelli, & Oyedele, 2020).

Big data is different from traditional data that is stored in databases (Amalina et al., 2020; Chen et al., 2014). Big data can be defined in multiple ways. But there are similarities in definitions in research. Big data consists of large datasets (Chen et al., 2014; Amalina et al., 2020; Klievink et al., 2017) from multiple sources (van Veenstra, Grommé, & Djafari, 2020; Klievink et al., 2017) that are available in (near) real-time (Chen et al., 2014; Ahmed, Tezel, Aziz, & Sibley, 2017; Tabesh et al., 2019).

These characteristics have been defined as the 3 V's (Ahmed et al., 2017; Baig, Shuib, & Yadegaridehkordi, 2019; Tabesh et al., 2019; Chen et al., 2014; Daniotti, Gianinetto, & Della Torre, 2020; Amalina et al., 2020):

Volume the amount of data

Velocity timeliness of the data

Variety different types of data

After the initial 3 V's, further research has added other characteristics, mostly in the form of additional V's:

Value what the data is worth for the perceived goal (Baig et al., 2019; Chen et al., 2014; Ahmed et al., 2017; Amalina et al., 2020)

Veracity the reliability and quality of the data (Baig et al., 2019; Tabesh et al., 2019; Ahmed et al., 2017; Amalina et al., 2020)

Variability inconsistency in the data flows (Baig et al., 2019; Daniotti et al., 2020; Ahmed et al., 2017; Amalina et al., 2020)

Valence connectedness of the data (Baig et al., 2019)

Complexity the effort needed to be able to analyse the data available (Baig et al., 2019; Ahmed et al., 2017; Amalina et al., 2020)

To be able to analyse the data a process is required. Klievink et al. (2017) describe the big data use process, four activities big data can be used in. Together these activities form a cycle, as seen in Figure 2.1. The first activity is collection of the data from various sources. After the collection, the next activity is combination, where the incoming data is processed, combined, organized and stored. This processed data is used for the activity called analytics, where the data is analysed and/or visualized and interpreted. The final activity is use: do something with the results from the analysis, for example producing insights, evaluating or making decisions. Since this process is performed continuously because of the constant inflow of new data, this process is a cycle.

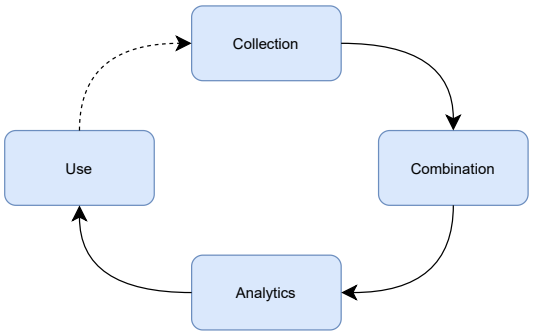

Figure 2.1: Big data use process as described by Klievink et al. (2017)

Tabesh et al. (2019) describe another cyclical process named the big data analytics cycle as seen in Figure 2.2. According to the characteristics above, the data is voluminous, diverse and continuously being generated. To be able to use it for decision making, the first step is to derive insights from the data. Nowadays, computing power available makes that a possibility. Based on those insights, decisions can be made. These decisions in turn lead to actions. Since the data is continuously generated, these actions are reflected in new data. This can be used to monitor the effectiveness and make new decisions.

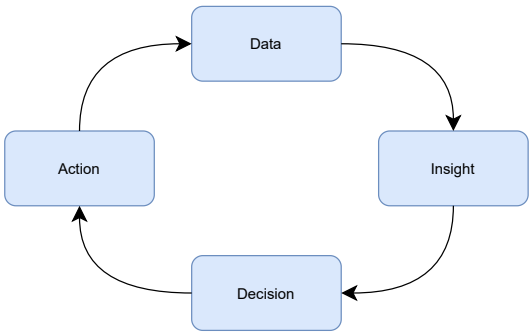

Figure 2.2: Big data analytics cycle as described by Tabesh et al. (2019)

The two processes are complementary. The use process described the path from data to use, effectively how to create insight by combining and analysing the data. This usage in the analytics cycle is decision making and the resulting action.

So, to be able to derive insights from data for evidence-based decision making, processing is a necessity. Data can be unstructured, semi-structured or structured (Amalina et al., 2020). Each of these forms of data require different types of processing to analyse this data. Structured data is stored in databases and can be queried. Semi structured data is for example third party data or weather information. This data requires processing but can be imported in databases for analysis. Unstructured data is varied and can be for example video, audio, social media,

images, reports etcetera. More complex methods such as artificial intelligence are involved in preparing this data for analysis (Baig et al., 2019).

A common conclusion in research is that big data analysis has a lot of potential for most sectors: cities, education, healthcare, military, business, transportation and government (Amalina et al., 2020). With this potential in mind, the next step is to determine the rate of adoption in, for this research, the public sector.

2.1.2 Big data adoption in the Dutch public sector

Big data analysis has high potential, if used correctly. However, implementation is not successful in the majority of cases (Tabesh et al., 2019).

Big data is not a purely technical exercise. The technical part is in preparing the data and analysing the data. That is collection, combination and analytics in the big data use process. However, to *use* the results of this analysis for insights, decision making and actions as seen in the big data analytics cycle, the organisation has to be able to act on the results from these analyses. Organisations that are able to master only the first part, may find the perceived gains to be less than expected if these organisations are not able to effectively act on the results of the analyses (Klievink et al., 2017) and risk becoming nothing more than owners of large datasets (Ahmed et al., 2017).

Big data is a topic of interest in many fields, including government. This is also the case in The Netherlands, which is one of the leading countries in e-government (Klievink et al., 2017). However, adoption of big data strategies in Dutch government is still in the early stages. As recent as 2017, no Dutch governmental organisations were considered ready for successful big data use (Klievink et al., 2017). The main reason is the described pitfall: Dutch government organisations are sufficiently capable to technically implement big data analysis, but lack the organisational capabilities to effectively act on the results of these analyses.

In their research on data analytics in the Dutch public sector, van Veenstra et al. (2020) have identified six types of applications currently used:

1. **Personalization:** personalizing government services.
2. **Resource allocation:** better use available resources by improving logistics.
3. **Maintenance:** identify (or predict) where repairs or maintenance are needed.
4. **Inspection and enforcement:** pattern recognition to prevent misuse of public funds or fraud.
5. **Crime investigation:** pattern recognition and prediction to detect possible criminal actions.
6. **Forecasting** macro-economic trend.

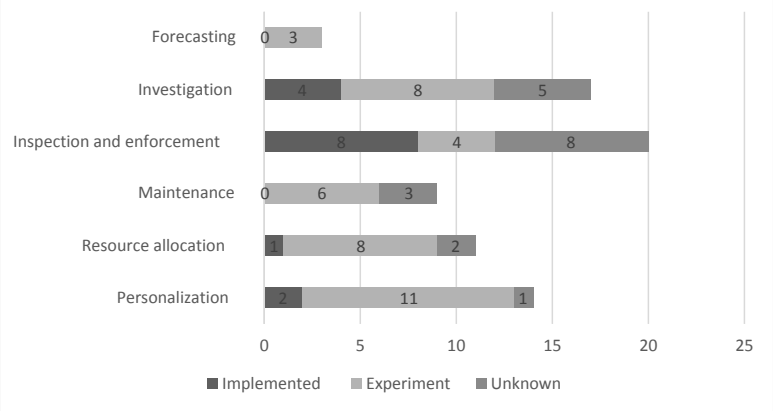

Figure 2.3: Various states of 74 big data projects in Dutch public sector (van Veenstra et al., 2020)

These where the result of reviewing 74 government projects using data analytics. As seen in Figure 2.3, of these 74 projects more than half were experiments or pilots, proving it is difficult for projects to move beyond this stage.

Klievink et al. (2017) in their research on big data in the Dutch public sector define three different applications:

1. **Object evaluation:** generating decision support information using advanced analytics and algorithms on multiple internal and external datasets and innovative use of existing data.
2. **Research:** generating new insights by performing advanced analytics and algorithms on internal and external datasets containing both structured and unstructured data.
3. **Continuous monitoring:** creating an enriched view on reality by innovative use of existing data and performing advanced analytics and algorithms on (near) real-time data.

Based on their research, they propose a public sector data readiness model, which they have used to determine the data readiness of 11 Dutch public sector organisations. There conclusion is that even though some of these organisations received a reasonably high score, even these had considerable work ahead to successfully implement big data strategies. None were close to a level in which big data strategies could be implemented on a large scale.

Big data analytics has multiple potential applications for the public sector. However, adoption is difficult, especially when scaling up. Research shows that this is not a purely technical issue. So for a successful implementation, it is necessary to identify requirements for big data analytics in organisations.

2.1.3 Big data requirements

As said in section 2.1.2, implementing a big data strategy is more than a technical challenge. Research has identified a multitude of requirements that influence the implementation of a big data strategy.

The requirements found in the research used for this project can be structured using the big data use process, as described in 2.1.1. Each phase brings specific challenges that need to be addressed.

In the *collection phase*, the emphasis is on collecting the data from various sources. An important requirement is to have ownership of the data, to be able to obtain it (Baig et al., 2019). This means that contracts have to be clear about the responsibilities in managing this data (Ahmed et al., 2017). Because data can also come from suppliers, it is also important to demonstrate to these suppliers the benefits (for example the return of investment) of data management (Ahmed et al., 2017). This is a constant process, because during the life cycle of various assets, different organisations collect data and therefore might own fragments of data (Ahmed et al., 2017). This is especially true for assets with long life cycles, for example real estate. The life cycle management of the data itself therefore is also important (Ahmed et al., 2017).

When data ownership is achieved, obtaining the data can be another challenge (Ahmed et al., 2017). An important consideration in this is security (van Veenstra et al., 2020; Ahmed et al., 2017; Amalina et al., 2020; Baig et al., 2019). Another important consideration in every phase is privacy in general (Amalina et al., 2020; Baig et al., 2019), but especially when using third parties for the collection of data (van Veenstra et al., 2020).

In the *combination phase*, data that has been collected and obtained is combined as a preparation for analysis. Lack of standardization can make this difficult and can be a challenge for structuring the data (Ahmed et al., 2017). Combining data also requires IT infrastructures that are expensive to build and maintain (Tabesh et al., 2019) and require specific staff skills (Ahmed et al., 2017; Tabesh et al., 2019) and interdisciplinary cooperation (Ahmed et al., 2017). Limiting data redundancy can help in reducing the amount of data and therefore the amount of infrastructure needed (Ahmed et al., 2017). As described in Section 2.1.1, big data is varied. This means that data by definition comes in many forms. This can be digital data, but even conventional data on paper. This can lead to interoperability issues (Ahmed et al., 2017).

In this phase, like the previous, privacy is again an issue, especially when combining datasets (Amalina et al., 2020; Baig et al., 2019) or employing third parties for processing the data (van Veenstra et al., 2020). The same goes for security, since in the combination phase all data is gathered in one place (van Veenstra et al., 2020; Ahmed et al., 2017; Amalina et al., 2020; Baig et al., 2019).

In the *analytics phase*, the combined data is analysed. The first challenge is finding suitable techniques and methods for this analysis(Amalina et al., 2020; Ahmed et al., 2017). Among this is an effective method for visual communication of data and the outputs of the analysis (Ladu, 2020; Ahmed et al., 2017). This

can also require costly IT infrastructure (Ahmed et al., 2017). In analysing data, it is important to remain objective and accurate, also because analysis is context dependant (Ahmed et al., 2017). It is therefore also necessary to be able to prevent bias, because that can influence decision making in the next phase (van Veenstra et al., 2020). Data quality (van Veenstra et al., 2020), for example ensuring data is not obsolete, is a challenge for this accuracy. This means that data analysis also requires skilled staff (Ahmed et al., 2017; Tabesh et al., 2019).

The final phase is the *usage phase*, where actions are performed based on the outcome of the analyses. To support this, it is important for decision makers to be willing to use data science as a source of information (van Veenstra et al., 2020; Tabesh et al., 2019). They have to rely not only on existing data sources, but because of the ever growing availability of data, also on new or emerging sources of data (van Veenstra et al., 2020). When the decision makers are using data, the organisational structure has to be flexible to support effective decision making. Because the process is a cycle, each decision leads to new data that can ultimately lead to new decisions. This requires flexibility (Ahmed et al., 2017). This also means that certain decisions can have negative consequences for operational employees (van Veenstra et al., 2020). Ultimately, it is important for organisational leadership to create a unified vision about the reasons for implementing a big data strategy and the effects it can have on the organisation. Ultimately the organisational culture has to support the big data strategy (Tabesh et al., 2019; Ahmed et al., 2017). This also requires management of talents and technology (Ahmed et al., 2017).

Klievink et al. (2017) in their public sector big data readiness model, identify seven "organisational capabilities for big data use": IT governance, IT resources, internal attitude, external attitude, legal compliance, data governance and data science expertise. Each of these capabilities, according to the authors, are needed for a government organisation to be ready to implement a big data strategy. This is combined with the organisational maturity in e-government and the organisational alignment (based on the main statutory task, for example administration or research).

2.1.4 Big data in public decision making

The final subject relevant for big data usage in the public sector is the decision making process in political organisations. In their research, van der Voort, Klievink, Arnaboldi, and Meijer (2019) conclude that big data can have a significant impact on public organisations, referring also to Klievink et al. (2017). They challenge the assumption that big data provides better information that in turn leads to better decision making. Instead they define two views. The first is the rational view. This view represents a process that is clear and in which big data enhances the steps which require information (van der Voort et al., 2019). The second view is the political view. This process is not clear, instead it is dynamic and erratic. In this process, political goals determine when, where and how big data can be useful (van der Voort et al., 2019).

The same research also defines two logics of information use, dependant on the viewpoint from which the decision making process is viewed. The information logic viewpoint is from those at the very start of the data use process (as described in Section 2.1.1). This is defined as the information logic viewpoint (van der Voort et al., 2019). In practice, these are the data analysts that oversee the data collection and provide high quality information to the decision makers. The quality of the information is controlled by adding a greater variety of sources, effectively using more data. The choices the data analysts have to make are methodological. Multiple options to improve the process by bringing in more technology are available (van der Voort et al., 2019). The other logical viewpoint is the decision logic: the viewpoint of the decision makers. Decision makers have to balance multiple ideas and based on selection determine their decision. The choices the decision makers have to make are more idealogical, based on competing values (van der Voort et al., 2019).

Based on the views and logics of information, four quadrants can be defined that give a perspective on the impact big data has on decision making in a political context, as seen in Table 2.1.

	Information logic	Decision logic
Rational/analytical view	**Quadrant 1: information optimization** Data analysts can rationalize processes by providing better data in a more accessible format	**Quadrant 2: decision optimization** Decision makers can rationalize processes by retrieving exactly the information they need for their decisions
Political view	**Quadrant 3: politics of algorithms** Smart algorithms provide data analysts the opportunity to influence outcomes while providing information to decision makers	**Quadrant 4: information market** Big data provides decision makers the opportunity to limit their dependence on information from specific sources

Table 2.1: Four perspectives that impact decision making (van der Voort et al., 2019)

Based on the perspectives, van der Voort et al. (2019) conclude that big data is more than a "simple" process that provides more information to decision making. Instead, both the decision makers and the information providers (data analysts) benefit from the data and gain power in the decision making process. It therefore can have significant impact on public institutions, further emphasizing the earlier conclusions from Klievink et al. (2017) that big data in the public sector requires significant organisational changes.

2.1.5 Big data: conclusion

The overview in this section was aimed to answer two sub-questions:

SQ2: What is the definition of big data and is this applicable to building based data?

SQ7: Can this data be used in public real estate management? In this case: what is required to be able to use this data in a public organisation?

For SQ2, various definitions for big data are found in literature. These vary from a base three characteristics to ultimately eight. The applicability to building based data was not present in the research found, that is what this project aims to contribute.

In the case of SQ7, literature is available about big data initiatives in the public sector. Usages, requirements and challenges are defined. An important conclusion is that big data projects have trouble rising beyond the pilot phase. This research aims to contribute to preventing that pitfall, by finding what data is required most. This makes it possible to focus initiatives on gaining that data specifically and also ensure there is sufficient need for that data so organisational pressure to reach beyond the pilot level may be higher.

2.2 Public real estate management

2.2.1 Real estate management

According to the Oxford English Dictionary, real estate is "property consisting of land and the buildings on it". Real estate can be owned by individuals (such as homes), but also by companies or governments: corporate real estate. For companies and governments, this real estate requires continual adjustment, not only because over time it deteriorates, but also because the real estate supply need to be matched to the demand, in terms of company goals or user goals (the primary processes). This continual adjustment requires resources, making it an economical process (Heijer, 2011). Real estate is considered a long-term and complex asset. It can be seen from various viewpoints, not only financial but also physical, functional and, most importantly, the potential usage of the property (Wojewnik-Filipkowska, Rymarzak, & Lausberg, 2015).

In recent years, corporate real estate has become regarded as an asset that influences the performance of individuals, organisations and even societies, not only in quantity but also in quality (Heijer, 2011). Because of this influence, resources are spent on this real estate (Heijer, 2011). Because real estate can cost substantial resources, the process of real estate management aims to measure that influence. This is

done before changes in real estate by making predictions, collecting data and creating future references. But also after these changes, by making new decisions based on available management information (Heijer, 2011). The aim of real estate management is to adopt the best possible solution for the various challenges involved via planning and checking and ultimately to achieve the goals of the organisation while using the resources available as efficient and effective as possible (Wojewnik-Filipkowska et al., 2015).

Real estate management is a decision making process. It aims to consider all stakeholders both on the supply side and demand side of real estate, from the strategic to the operational level. The process of management can be visualised as seen in Figure 2.4. An essential component of this process that is required by decisions makers is information (Heijer, 2011). The end result, the real estate strategy, should at least have the following components:

- Analysis of the requirements of all stakeholders and of the surrounding conditions.
- General strategy and partial strategies for all important areas.
- Real estate strategy for all levels, from the tenant to the portfolio level.
- Investment and finance strategy.
- Organisational and technological strategy (Wojewnik-Filipkowska et al., 2015).

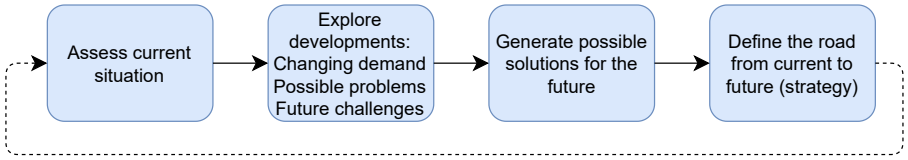

Figure 2.4: The steps in the management process based on Heijer (2011)

Muczyński (2015) states that real estate management involves not only making decisions, but also undertaking all the necessary activities to maintain the proper condition of this real estate, where *proper* is in compliance with the purpose for the real estate. This includes making justifiable investments in real estate. This research defines different levels of real estate management:

- Investment/corporate level: real estate investment management.
- Portfolio level: real estate portfolio management.
- Object management level: day-to-day management, consisting of:
  - strategic object management: real estate asset management.
  - operative objective management: proper management and real estate facility management (Muczyński, 2015).

All of the above involves corporate real estate in general. While there are a lot of similarities between corporate real estate management and public real estate management, there are also some important differences. This is explored in the next section.

2.2.2 Corporate real estate management and public real estate management - similarities and differences

As in corporate environments, governments also have to manage their real estate. Matching the real estate supply to the organisational demand is still an important goal, which in corporate real estate management is primarily an economic driven process. For governments however, economic drivers are present, but other drivers are societal and political goals (Heijer, 2011).

An important reason is that the incentives of government organisations are different from business organisations. In the latter, profit is the main incentive for the leadership and the most important stakeholders are shareholders and customers (van der Schaaf, 2002). In governments, the main incentive for the leadership is to be re-elected. This means that in governments there are three major stakeholders: the treasury for the financial goals, the users of the real estate for having suitable environments to work in and the politicians for the political goals (van der Schaaf, 2002). And apart from these internal stakeholders, governments have to deal with a lot of external stakeholders: the general public has opinions

about what is done with tax money and numerous special interest groups want to have influence on government policies, some even conflicting (van der Schaaf, 2002).

As is the case for corporate real estate, public real estate is an expensive asset that has a major influence on the revenue and debt policy of governments (Wojewnik-Filipkowska et al., 2015). But where businesses get their money from customers, governments get their money from taxes. And because governments are monopoly-driven as opposed to businesses being competition-driven, return on investments is seldom an issue (van der Schaaf, 2002). This means government buildings are rarely seen as investments (van der Schaaf, 2002). Government real estate contains numerous properties that are mandatory and therefore unprofitable (Wojewnik-Filipkowska et al., 2015). The goals of public real estate are defined by the public tasks they perform (Muczyński, 2015). In the case of the Dutch government, these are for example prisons, palaces and defence installations. Some buildings have more than economical value: they are historic buildings which have to be preserved or have some form of amenity value (Montfort, 2017). These buildings have political value or a symbolic meaning (van der Schaaf, 2002). To place a value on these kinds of real estate is much more difficult than placing a value on, for example, a generic office building (Wojewnik-Filipkowska et al., 2015).

Public real estate needs to be based on more than financial consequences. Societal demands and effects are an important consideration (Montfort, 2017). This is because changes within governments are not aimed at improving the organisation, but instead are aimed at solving problems in society, or even to avoid these problems. Because public real estate has to support these government goals, public real estate management is directly influenced by changes in the strategy of governments. Changes in policy often have impact on the real estate policies (van der Schaaf, 2002).

An example is the global financial crisis and subsequent Eurozone crisis, roughly the period 2007-2014. In this period the Dutch government had to drastically cut its expenses, which meant a new policy was enforced to drastically reduce the amount of real estate. This is in this case primarily an economical motive. However, the Dutch Council for the Environment and Infrastructure is an important advisor for the Dutch government. In this case they advised the Dutch government (see Figure 2.5) to not only think of the financial goals, but also to keep in mind the societal goals. For example to sell buildings not to the highest bidder but to buyers who contribute to society with this building. And to also account for the effect this divesting of real estate has on the local commercial real estate markets (Council for the Environment and Infrastructure, 2014).

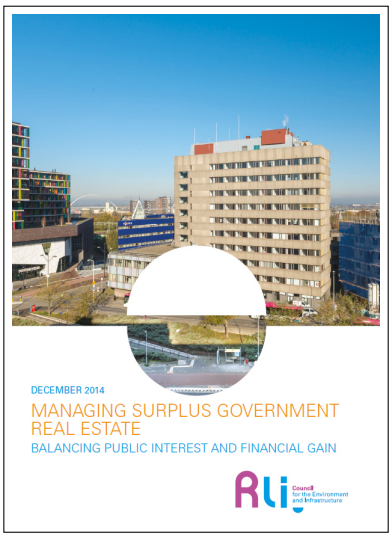

Figure 2.5: Report of the Dutch Council for the Environment and Infrastructure on divesting Dutch public real estate

As the example above illustrates, there is a clear relation between the strategy of governments and the strategy for their respective real estate (van der Schaaf, 2002). And this strategy in turn, is influenced by internal and external factors. Internal factors are the power of parties, which may change with every election and as in the example above the financial position of the government. External factors may be the current state of the economy, current societal themes and technological developments (van der Schaaf, 2002).

Also, public real estate management is very different per country (Kaganova & Amoils, 2020). Every nation has cultural differences which greatly influence the political strategies which in turn, as said, influence real estate strategies. For the Dutch government for example, historically disappointing economic growth is a big influence in government policy (van der Schaaf, 2002). Economic problems have had major influence on Dutch real estate policy.

Another example is the emergence of New Public Management (NPM), which resulted in a different view on governance within the government (van der Schaaf, 2002). NPM has been an important driver for the concept of public real estate management (Wojewnik-Filipkowska et al., 2015). NPM comes from the idea that governments increase efficiency by taking the private sector as a model. Important characteristics for NPM are decreasing the size of the government, stimulate bureaucrats to act more like entrepreneurs and try

and improve excellence in various government organisations (van der Schaaf, 2002). For public real estate, this could for example be that as is the case within the Dutch government, organisations pay rent for the real estate they use to another governmental organisation. This has to be proven to work well (Wojewnik-Filipkowska et al., 2015). However, since as described above a lot of public real estate effectively has limited or even no economic value, in a lot of cases a simple risk-return model does not work (Wojewnik-Filipkowska et al., 2015).

Real estate management is a management process, which as described in Section 2.2.1 requires decision making. Metrics are needed for these decisions, but these depend on the purpose, durability and functions of real estate (Wojewnik-Filipkowska et al., 2015). In public real estate, these metrics are also dependant on specific government policies and strategies, as per the examples above (Wojewnik-Filipkowska et al., 2015). With the knowledge that there are many similarities but also differences between corporate and public real estate management, it is therefore to be expected that public real estate management brings its own set of unique challenges. The next section aims to provide insight in these challenges.

2.2.3 Managerial challenges in public real estate management

As described in Section 2.2.2, public real estate management is different from corporate real estate management because of the difference in stakeholders and their respective goals. Hence, these stakeholders also influence the managerial challenged faced in the management of public real estate. Three stakeholders are defined by van der Schaaf (2002), each with different interests concerning the public real estate:

1. **Users;** Partly because of the ideas of NPM there is a financial relationship between the users and the real estate owner: they pay for the accommodation they use. That makes them a critical factor (van der Schaaf, 2002). They are often satisfied with the buildings itself but less so with the services provided and the processes involved.
2. **Ministry of Finance;** The main interest is financial efficiency: to minimise the funds that are spent on government real estate.
3. **The government;** To politicians; as said earlier, the main goal is to get re-elected. This means that the interest is for real estate to contribute to political goals in various fields, for example architecture, urban planning, monuments and sustainability. This is done by setting examples using public real estate.

Each of these stakeholders bring different challenges for management of public real estate. These problems can be divided in multiple fields (Wojewnik-Filipkowska et al., 2015). An overview is given in Table 2.2.

Strategy related problems are challenges on the strategic level of real estate management. The general conclusion is that strategy in public real estate management is often insufficient. There is no clear, articulated strategy or a distinct separation between strategic and operational management. This results in a fragmented, incidental and reactive type of management (Wojewnik-Filipkowska et al., 2015). Best practices from other public organisations are not implemented and there is a lack of coordination (Wojewnik-Filipkowska et al., 2015). Also, public real estate is often behind on the private sector, for example in sustainability, methods of construction or the way of operating the buildings (Wojewnik-Filipkowska et al., 2015).

Portfolio related problems are challenges in the way the public real estate portfolio is managed. For this, data is needed but in public real estate this is mainly limited to legal and technical data. Most of this data is also outdated (Wojewnik-Filipkowska et al., 2015). For portfolio management economic data is needed, and the data that is available should be up to date. This means for example that no strategic decisions about buying or selling real estate are possible. Instead, most public real estate is managed by budget (Wojewnik-Filipkowska et al., 2015). Portfolios have to be reviewed frequently to determine unnecessary or unfitting properties. Frequent reviews also reveal other typical problems like underutilized (or vacant) properties or properties that can be marketed when budgets are needed (Wojewnik-Filipkowska et al., 2015).

Finance related problems are challenges that are related by financial causes. For public real estate, this can be ad hoc political decisions. Government real estate is sometimes used to generate funds to help create the budget that is needed (Wojewnik-Filipkowska et al., 2015). Public real estate management also lacks risk management, even though apart from financial risks (like in corporate environments),

there are also political risks (damage in reputation), fiscal risks and contingent liabilities that can occur (Wojewnik-Filipkowska et al., 2015). Last, monitoring or even forecasting of markets is almost non-existent. This results in problems in the valuation of the public real estate portfolio: it is inadequate, inconsistent, incomplete or a combination of these. This in turn results in a lack of reliable data that should be used to determine fair rents and agreeable sale or buy prices (Wojewnik-Filipkowska et al., 2015).

Finally, there are *organisational and technological* related problems. Challenges faced by changing technology or organisational barriers. The shift from asset-intensive real estate management to information-intensive is not yet widely made in public real estate management. This shift creates possibilities for simulations by complex analyses of various data. This however requires both the data and the tools to perform these analyses, which are mostly not yet present in public real estate management (Wojewnik-Filipkowska et al., 2015). Technology is a driver for computerization, which in corporate environments has resulted in various tools for enterprise resource planning, portfolio management, risk management and customer relation management. Because of both financial and organisational reasons, public organisations are lagging in implementing these tools (Wojewnik-Filipkowska et al., 2015). Lastly, in public real estate the properties are owned and managed by multiple independent entities. This results in insufficient control and fragmented management of the portfolio (Wojewnik-Filipkowska et al., 2015).

Strategy problems	Fragmented
	Incidental
	Reactive
	No clear strategy
Portfolio problems	Data unavailable
	Data outdated
	Managed by budget most of the times
	Underutilized properties
Finance problems	Ad hoc political decisions
	Lack of risk management
	No reliable data to determine fair rents
Technological problems	Shift from asset-intensive to information-intensive
	Implementation of modern IT tools
	Managed by multiple entities

Table 2.2: Challenges in public real estate management found in literature

2.2.4 Public real estate management: conclusion

This section focused on finding literature related to four sub-questions:

SQ1: What is the difference between public real estate management and commercial real estate management?

SQ3: What challenges are found for decision making in strategic real estate management?

SQ4: What information is required for these decisions?

SQ7: Can this data be used in public real estate management?

For SQ1, literature describes distinct differences. The inclusion of political influence and decisions is an important difference between commercial and real estate management. The influence of these decisions on the strategic decisions in scope for this project are not specifically mentioned in literature, that is part of this project.

Multiple challenges on different levels are identified and can be used for SQ3. An overview is given in Table 2.2. This research determines the occurance of these challenges in the strategic real estate process.

Information used in decision making is scarcely mentioned in the literature on real estate management. The transition from asset-intensive to information-intensive is an identified challenge. The problems with data, especially having the availability and accuracy of information, also are there. By researching the data needed for this process, this project contributes to this gap in literature.

Finally, for SQ7, real estate management is defined as a process where information is needed. What information is needed, as mentioned, is not found. But the fact that the process requires information confirms that data could be used. This project is based on that hypothesis and further explores the information that is actually used and required.

2.3 Building based data

2.3.1 Available datasources

Modern buildings contain many systems that generate data. Burak Gunay et al. (2019) differentiate between emerging data sources and established data sources, as seen in Figure 2.6. The difference between the two is that in established data sources the communication protocols for the exchange of data and the storage of the data are relatively standardized (Burak Gunay et al., 2019). The systems where this data comes from are also mostly already in control (owned) by the property owner. The first one is the building automation system (BAS), that operates the buildings installations: heating, ventilation, air-conditioning and cooling (HVAC). The second one is lighting, that sometimes uses separate systems but can also be integrated into the BAS. Third is metering: meters that measure usage of various utilities like energy or water (Burak Gunay et al., 2019).

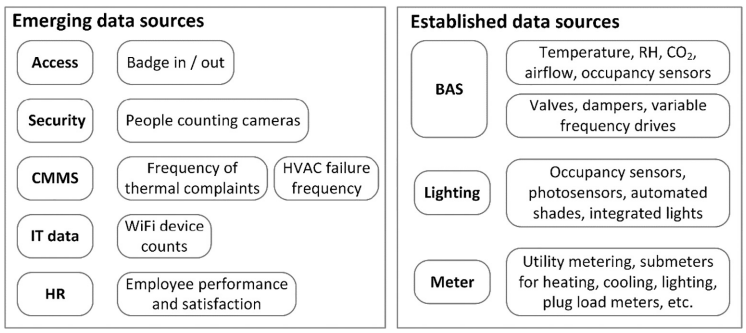

Figure 2.6: Emerging and established datasources in buildings (Burak Gunay et al., 2019)

The other type are emerging data sources. These are various data sources that may originate from different organisational sources: IT, security, HR, etcetera. They contain data that may be relevant for property owners, but is generally used for different purposes (Burak Gunay et al., 2019). Among these are access and security systems which are used to regulate who can enter the building (and various zones within the building) and to provide security through cameras, door sensors and movement sensors. The services provided by IT can also be used to generate data, for example the Wi-Fi network. Human resources can provide insight in people-specific information like performance, health or satisfaction (Burak Gunay et al., 2019). And finally, data can come from management systems, for example the computerized maintenance management system (CMMS) that is used to monitor maintenance status and register failures and complaints (Burak Gunay et al., 2019). Another emerging trend is the use of low power wireless sensors, that in the future can increase the availability and reliability of data in properties (Burak Gunay et al., 2019).

To be able to analyse the data from both established as emerging data sources, it is necessary to be able to collect and combine the data, as seen in the big data use process (Klievink et al., 2017). This can be problematic, even for the established sources. The data in these systems is used for their primary purposes. Access control systems are used to, as the name says, control access. A BAS is used to control the indoor climate. The data is not intended for analytics (Burak Gunay et al., 2019). This provides various challenges for the collection phase, for example most data is only stored for a limited period of time because it is not necessary for the primary purpose (Burak Gunay et al., 2019). It also provides challenges for the combination phase, for example because there is not a standardized way of labelling the data and thus this will most likely be different for each building (Burak Gunay et al., 2019). Other challenges for the data are privacy and security concerns that can occur, mainly in the case of human resources or security data (Burak Gunay et al., 2019).

2.3.2 Comparability to big data

The comparability of building data to big data seems an unexplored research area. This can be explained by the fact that research on big data in the built environment sector is very limited (Ahmed et al., 2017). The Internet of Things (IoT) is often named as a main driver behind the growing amount of data, and the IoT is also emerging in the built environment (Ahmed et al., 2017; Daniotti et al., 2020). As seen in Section 2.1.1, the definition of big data is more than simply "a lot of data".

The research available gives insight in the data available. As seen in the definition, big data has multiple characteristics, but the initial 3 V's are volume, velocity and variety.

As for variety, as described by Burak Gunay et al. (2019), multiple data sources are available in buildings that can be used for various insights. These sources can have large amounts of data, for example in the case of building automation systems (Burak Gunay et al., 2019). So the volume characteristic is applicable too. Finally, for velocity, most data in buildings is dynamic and being generated in real time. This is the case for building automation systems, which have to control the building in real time. But also for security systems and other systems (Burak Gunay et al., 2019; Daniotti et al., 2020). So based on the research available, building data can be considered big data according to the most basic definition.

As seen in the big data use process (Klievink et al., 2017), big data needs to be processed before it can be analysed. The difficulty in processing is also reflected in the complexity characteristic. This is also the case for building data: building automation systems for example contain databases but those were never designed with analytics in mind (Burak Gunay et al., 2019). Most building automation systems therefore only store data for a brief period of time (weeks) (Burak Gunay et al., 2019). The fragmentation can also be a challenge to create required insights. As will be seen in the next section, occupancy data is an important metric. But this data can be collected from various, fragmented, data sources (Burak Gunay et al., 2019). So, the data available needs to be gathered, processed and analysed before insights can be gained, the same as other big data.

2.3.3 Usage scenarios and data needed

Research is available on using data for various areas of real estate management. On a strategic level, data can be used to measure key performance indicators (KPI's). Because of the complexity of real estate management, these can be necessary to benchmark with other similar organisations (Heijer, 2011).

Over the past decades, interest in KPI's within public real estate management has increased (Kaganova & Amoils, 2020), also because of the increased availability of technology to gather and store more data (Burak Gunay et al., 2019). According to Kaganova and Amoils (2020) however, there is little agreement between public real estate organisations about the KPI's that are used: in government KPI's for this goal are defined mostly without a strategic approach. This is further underlined by Burak Gunay et al. (2019) by stating that no research is as of yet available what KPI's are be able to influence the makers of decisions.

In literature, multiple KPI's are defined. Each of these KPI's give insights on information used in strategic real estate management. An overview of the KPI's that are named in the research are in Table 2.3.

The KPI's in Table 2.3 are intended for decisions on a strategic level and to benchmark to comparable organisations. In literature use cases for data are defined. These are intended to provide information for these KPI's, or directly influence these: for example to significantly reduce the costs of daily operations (Ahmed et al., 2017; Daniotti et al., 2020; Burak Gunay et al., 2019). As seen in Section 2.3.1, some of these data sources are emerging just recently. These can give information about topics that were until recently considered immeasurable (Burak Gunay et al., 2019). This in turn enables new information towards the KPI's mentioned.

An example is information about building occupancy. Multiple data sources can be used to measure the amount of people in a building and in some cases even differentiate within the building. Security and access control systems are one of these. Processing images from security camera's, measurement of access cards used and monitoring entry and exit events at doors, stairs and elevators all contribute to insight in occupancy (Burak Gunay et al., 2019). Additionally, IT systems can also provide further insight by measuring the amount of devices connected to Wi-Fi networks or Bluetooth signals from mobile phone (Burak Gunay et al., 2019). Lastly, the BAS can provide information about occupancy on room level

KPI	Insight	Source
Floor space per FTE	Effectiveness of property use	Kaganova and Amoils (2020)
Vacancy rate	Effectiveness of property use	Kaganova and Amoils (2020); Wojewnik-Filipkowska et al. (2015)
Annual operating and maintenance cost per m^2	Efficiency of property use	Kaganova and Amoils (2020)
Property condition	Condition of assets	Kaganova and Amoils (2020)
Management costs	Efficiency	Kaganova and Amoils (2020); Burak Gunay et al. (2019)
Customer (tenants) satisfaction	Quality	Kaganova and Amoils (2020)
Energy efficiency	Performance	Burak Gunay et al. (2019)
Indoor environment quality	Performance	Burak Gunay et al. (2019)
Greenhouse gas emissions	Performance	Burak Gunay et al. (2019)

Table 2.3: Key Performance Indicators used in strategic real estate management.

by analysing temperature and humidity, the state of lighting and CO_2 values. The information about occupancy can be used to control lighting, to save energy. When occupancy can be forecasted, it can also be used to more efficiently control the building climate (Burak Gunay et al., 2019). This contributes to energy control and influences the KPI's on building performance (Wong, Ge, & He, 2018). It can also be used to provide insight in the effectiveness and efficiency of the property use because it gives insight in space utilization (Burak Gunay et al., 2019).

Customer complaints influence satisfaction and the KPI quality. Interactions with climate control units can give insight in the perceived comfort (Burak Gunay et al., 2019). Data can also be used to more accurately control building systems by using data from external sources, such as weather predictions (Daniotti et al., 2020). Load forecasting can also be employed to predict cooling and heating demand. This in turn increases building efficiency and reduces energy usage (Burak Gunay et al., 2019).

There is a connection between complaints and building performance (Burak Gunay et al., 2019). Building performance can also be influenced by predictive maintenance: use data to predict the necessity of maintenance of building components. Traditionally, maintenance is performed heuristically and in a conservative manner, which means it is often done too frequently (Burak Gunay et al., 2019). Predicting maintenance helps in preventing downtimes but also helps reduce resource waist (Ahmed et al., 2017; Daniotti et al., 2020).

2.3.4 Building based data: conclusion

This section focused on finding literature related to three sub-questions:

SQ2: What is the definition of big data and is this applicable to building based data?

SQ4: What information is required for these decisions?

SQ5: What building data is available?

SQ6: Can building data provide the required information?

For SQ2, extensive research is available on using data from building based systems for various scenarios, based on the premise that it is comparable to big data. Based on the definition, this is further explored in this project.

The information required for real estate decisions is not primarily found in literature. However, multiple KPIs that can be used in answering SQ4 are available. These in turn contain data that can be used to gain insights. This project aims to further answer this question by researching the data most needed in decisions.

For SQ5, an overview of current and emerging data sources was found in literature. The applicability of these sources to government offices is done in this project.

For SQ6, finally, this is not answered in literature. While an overview of data and corresponding use cases is given, the data that can be used in strategic real estate decisions is not explicitly identified.

Chapter 3

Research methodology

3.1 The structured-pragmatic-situational approach

3.1.1 Introduction and justification

The research methodology for this project is the structured-pragmatic-situational (SPS) approach (Pan & Tan, 2011). This is a case-study methodology using qualitative analysis based on the idea that having access to an organisation is the key to performing research, because gaining access is a difficult process.

The research methodology was published in the UK based peer-reviewed journal of Information and Organisation[1], that publishes research about information technology and the effect it has on organisations. The paper that introduces the methodology (Pan & Tan, 2011) is, based on Google Scholar, referenced nearly 500 times. Of these, multiple papers that reference this methodology are comparable subjects: emerging technology and the roles in certain organisations (T. Q. Sun & Medaglia, 2019; Ye, Pan, Wang, Wu, & Dong, 2021; Tim, Hallikainen, Pan, & Tamm, 2020; Baig et al., 2019).

The SPS approach aims to address common criticism on the use case methodology. At first, it is a **structured** method divided in eight steps that are specified in detail and repeatable. Second, it is **pragmatic** because it incorporates methods techniques to make the process less complex without sacrificing academic requirements. Last, it is **situational** because it is flexible and adaptive to common issues that can occur in the process.

As explained by Pan and Tan (2011), the case research method is "especially appropriate for examining complex phenomena, processes, and addressing *how* and *why* questions". This fits this project. It studies two complex phenomena: public real estate management and big data strategies. The aim of the research is to find the benefits of big data for the decision making in real estate processes. And the research question is essentially a *how* question. And not in the last place, the access to this specific organisation is already gained.

3.1.2 Research process

Figure 3.1 is the graphical representation of the SPS approach. It contains eight defined steps in two cycles, with clear boundaries between the two cycles.

The first and foremost step is gaining access to an organisation. For this project, that is the CGREA, and where needed other government organisation that are accessible by available contacts, such as the National Police or the Municipality of The Hague; different organisations with a large public real estate portfolio.

This is the requirement to enter the first cycle: the *framing cycle*. The goal for this phase is the creation of a theoretical lens. Through the various steps, information about the selected organisation and the subject of the research are being researched. This is done in first by analyzing non-scientific literature like reports, but also the internet. This is combined with scientific literature that is applicable

[1] `https://www.sciencedirect.com/journal/information-and-organisation`

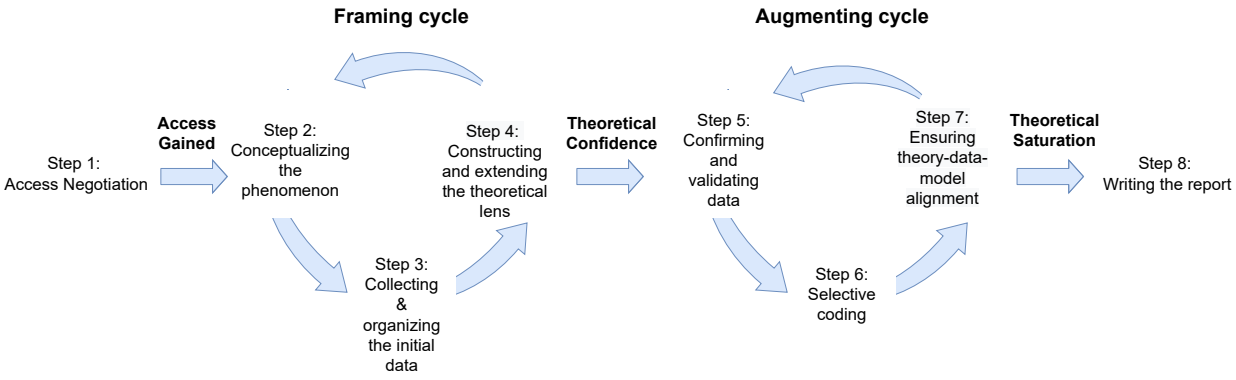

Figure 3.1: The structured-pragmatic-situational approach (Pan & Tan, 2011)

to the research subject. In this way, a concept is created of the perceived phenomenon that is researched. Multiple theories can be explored in this phase.

Organizing the collected data is important, to adhere to the **structured** part of this research approach. After the inital collection and organisation, the theoretical lens is constructed and extended using interviews. These interviews are used to gain a more complete view of the organisation and the phenomenon. The interviews are not yet used to verify the research theory, because that is the next phase. Interviews can lead to further insight in the phenomenon and possibly more data. This cycle continues until a state of *theoretical confidence* is gained: the "accurate representation of the empirical reality" (Pan & Tan, 2011). Part of this theoretical confidence is the selection of a dominant theory that is used in the next phase. Theoretical confidence should mean that it is not to be expected that new categories are added to the theoretical lens. This representation of the empirical reality is called the (emergent) model, effectively the subject of the research.

For this project, the sub-questions defined in Chapter 1, leading to the literature analysis in Chapter 2 are used to create the theoretical lens, which is further completed with interviews.

Gaining theoretical confidence is the requirement to enter the second phase in the research: the *augmenting cycle*.

The augmenting cycle is used to validate the data and, through a process of selective coding, ensure the alignment between the theory, the data and the model. The phase starts with interviews to confirm the data that was found in the first cycle. The goal is to transform the lens into a proper theory by finding evidence while also making sure the data is valid. Pan and Tan (2011) propose to apply the principles of suspicion and validity by Klein and Myers (1999). This is done by finding at least two data sources (for example interviews) to for every piece of information that supports the theory. To do this, selective coding is employed to gather enough empirical evidence for each category.

After these steps, the final important step is alignment. According to the authors, the theory-model-data alignment is in fact reached by three separate alignments which can be summarized by three questions (Pan & Tan, 2011):

Theory-data alignment: "Can the case data be explained by existing theories?"

Data-model alignment: "Does the data support the emergent model?"

Theory-model alignment: "Do existing theories support the emergent model?"

The augmenting cycle is completed when the researcher reaches a point of *theoretical saturation*. Part of this point is having gathered sufficient data. According to Pan and Tan (2011), key signals are significant overlaps in the collected data or problems in further extending the model in a meaningful way. When this is the case, the case report can be written. The SPS approach also gives a structured outline for the report, that was adopted for this report.

3.2 Case selection criteria

The case organisation for this research is the CGREA. There are multiple reasons why specifically this public real estate owner was chosen.

The author of this thesis is employed with the CGREA. As previously mentioned by Pan and Tan (2011), gaining access to organisations for research is often the most difficult part. By performing this research with the CGREA as the main subject this requirement was met. It was also helpful in gaining access to key people for the interviews.

CGREA has started initiatives on the subject of big data. Even though the projects are in the starting phase, initial steps have been undertaken and knowledge has been developed. This was also described in Section 4.1.3. This increased the changes to find an answer to the research question. Not all public real estate organisations have started these initiatives, as seen in the interviews with other organisations.

CGREA is the largest public real estate owner in The Netherlands. Products and processes that are developed by the CGREA are often adopted by other public real estate owners. The building inspection method RVB-BOEI for example, was developed by the CGREA and is used in other organisations, as mentioned in the interview with the National Police.

References are used to further justify the empirical approach. Though the primary case is the CGREA, reference interviews were held with two other large public real estate onwers: the municipality of The Hague and the National Police. This to ensure a broader view of the subject.

Too many international differences. The focus for public real estate on a national level as opposed to an international level, was made by the knowledge that there are significant differences in international public real estate management (Kaganova & Amoils, 2020; van der Schaaf, 2002). Because of the differences, it is to be expected that strategic decisions differ also. For that reason the focus was on Dutch public real estate.

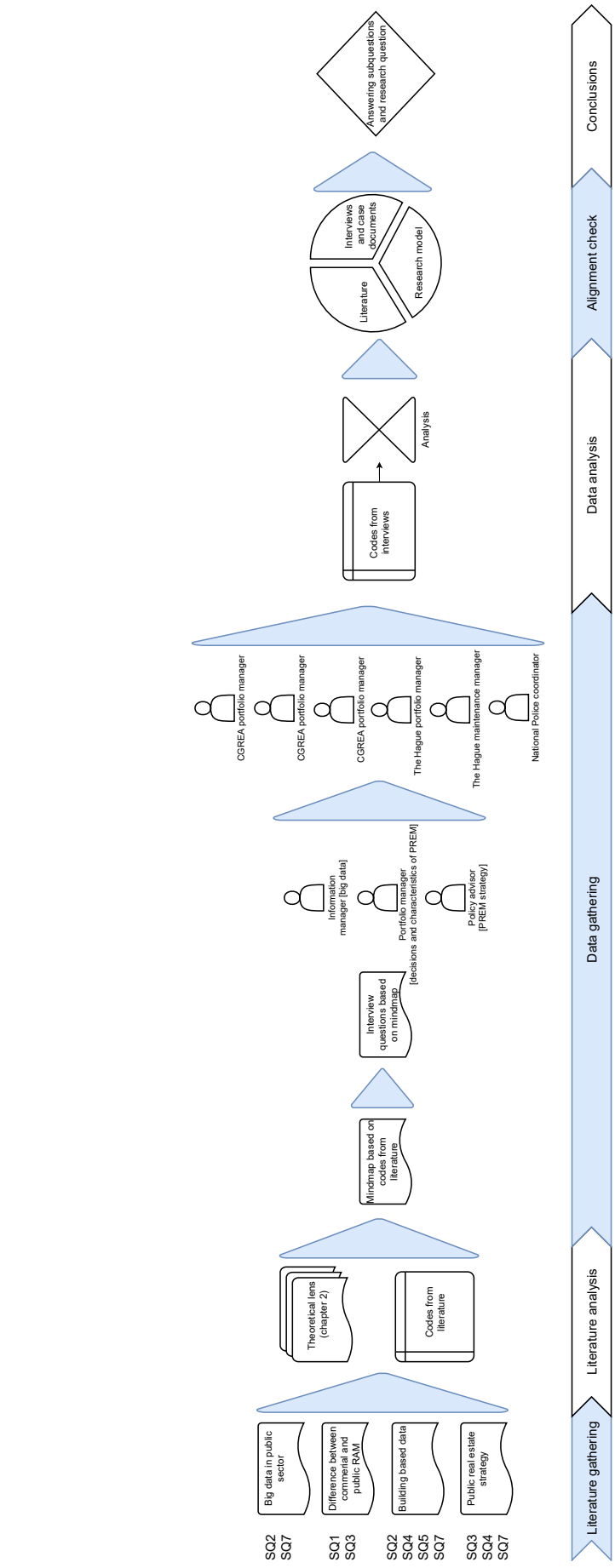

Figure 3.2: Graphical overview of the research process

3.3 Details of data collection

The data collection for this research follows the methodology chosen. A graphical overview of the research process, based on the chosen methodology, is presented in Figure 3.2. The subsequent sections contain fragments of this graphical representation: theoretical lens, data gathering and analysis. The goal of the following sections is to describe the process in detail, to prove the academic approach and provide insight in the structured process to ensure repeatability.

This section describes the details of the collection of the data used to answer the sub-questions. The first step is forming the theoretical lens by gathering and analysing literature, which resulted in Chapter 2. The second step is data gathering, using interviews to both verify the theoretical lens and subsequently collect data from interviews for further analysis. This analysis is the final step, where coding is used to systematically analyse the interviews, answer the research questions and verify alignment.

3.3.1 Theoretical lens

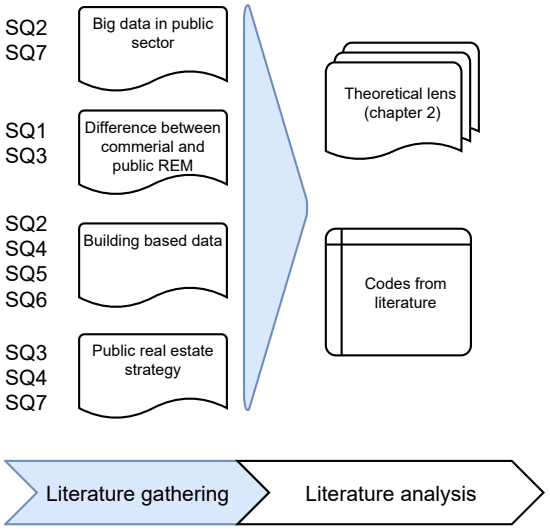

Figure 3.3: Fragment of research process: literature analysis

Figure 3.3 is a graphical representation of the first step, forming the theoretical lens. It started with a search for relevant literature on the subject and collecting it in Mendeley[2]. This was done by starting a query on Google Scholar and the Leiden University Library for literature in four topics. These topics are based on the sub-questions from Chapter 1, where each topic is based on multiple of these questions:

SQ2 and SQ7: big data adoption in the public sector and drivers and barriers associated with that.

SQ1 and SQ3: public real estate management - differences with commercial real estate management.

SQ2, SQ5 and SQ6: public real estate management - challenges in public real estate strategy.

SQ3, SQ4 and SQ7: building based data - the comparability to big data and usage scenarios.

Various queries with these keyword were used, where results were initially limited to recent research: 2019 and further. Where the search results yielded too many results, more keywords were added to further lower the number of relevant documents. When an acceptable number was reached (20-30), all search results were scanned for the relevancy to this research. This yielded an initial set of relevant research documents.

In the next step, the references in the initial set were studied. The papers that were relevant to the research subject where then retrieved and read. This yielded a second set of literature. This was often older research with fundamental insights, like the dissertation on public real estate management (van der Schaaf, 2002).

[2] `https://www.mendeley.com/`

Parent code	Code	Total
	Big data adoption	8
	Important	16
	Possible further research	6
	Real Estate Management definition	25
	Difference public RAM / commmercial	29
	Challenges in real estate management	11
	Decisions in real estate management	12
Real Estate Management definition	New Public Management	9
	Data needed in PRAM	10
	Scenario's for data	29
	Available data sources in buildings	6
	Challenges for building data	9
Data needed in PRAM	KPI	9
Challenges in real estate management	Challenges in PRAM	13
Real Estate Management definition	International differences	1
	Dashboards	3
	Motivations for using data	9
Real Estate Management definition	Facilities management	3
	RVB Info	8
RVB Info	Parallel definitie PREM	6
	real estate definition	3
	Drivers for big data	21
	Inhibitors for big data	29
	Big data definition	29
	Usages for big data	19

Table 3.1: Codes used in the literature review, exported from MAXQDA

The final step was to search for the documents in the second set in Google Scholar and scan the literature that references that specific research and, additionally, check the other papers published by the same authors. This yielded a very small additional set of literature, but mostly containing very few additional relevant information. This, combined with the fact that the research also yielded papers that gave an overview of relevant research it itself (Burak Gunay et al., 2019), gave the confidence that theoretical saturation was reached.

Next to the scientific literature, CGREA and other government documents were also collected. Because of the knowledge the author has with the CGREA, this was a step not requiring many interviews to determine the various initiatives and processes in the organisation. The relevant documents were also stored. The official process descriptions on the CGREA intranet were also studied. This to ensure multiple sources for case data were used (documents and interviews) as described in the research methodology, to prevent bias.

The next step was to structurally study the set of literature found. To this end, codes were used. Both the scientific literature as the CGREA documents were loaded in MAXQDA[3]. With the research questions in mind, the documents were read and codes were applied to relevant sections of the texts. An overview of these codes can be found in Table 3.1

Based on the codes and the literature, the literature in Chapter 2 was written and used to complete the theoretical lens.

[3] https://www.maxqda.com/

3.3.2 Data gathering

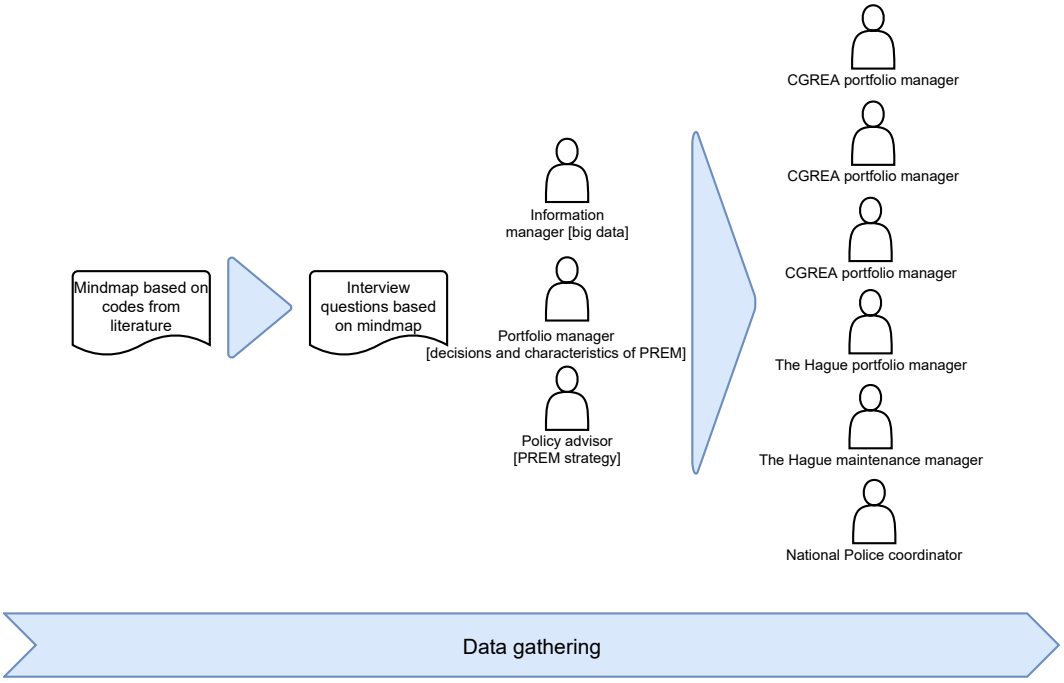

Figure 3.4: Fragment of research process: data gathering

After the initial completion of the theoretical lens, the next step was to perform interviews to both confirm the findings in the literature and to further test the emerging theoretical model. This step is represented in Figure 3.4. The literature brought a focus in the research on the three subjects of public real estate management, big data initiatives in government and the possibilities of data from building systems. To prepare for the interviews, the literature analysis was used to make a mindmap in a trial version of XMind[4]. This mindmap helped structure the literature and determine the interview questions. This mindmap can be found in appendix C.

An initial set of interviews was held with three stakeholders. The stakeholders chosen were based on the three subjects.

CGREA information manager involved in big data program	To verify the theoretical data for the subjects big data and building based data.
CGREA policy advisor real estate strategy	To verify the theoretical data primarily for public real estate strategies but also the characteristics of public real estate management
CGREA coordinating portfolio manager	To primarily verify the theoretical data on characteristics of public real estate management but also public real estate strategy.

The interviews were planned in the subjects' online calendars with a digital invitation. To prevent bias, the introduction to the subject was kept in general (translated from Dutch):

"For my study ICT in Business and the Public Sector I am researching the role of big data in strategic public real estate management. I aim to research if data from building based systems can provide insights that contribute to strategic decisions that are made in (primarily) the office portfolio. No preparation is necessary. If it's not a problem, I will be recording the interview (audio only) for transcription later."

Because of the COVID-19 crisis, all interviews were held online using the government's digital meetings tool. Only audio was recorded using OBS Studio[5] and only after asking for explicit permission from the

[4] https://www.xmind.net/
[5] https://obsproject.com/

person being interviewed. Only the interview itself was recorded, not the introduction before and the closing conversation. All interview were held in Dutch, not in English.

The interviews were transcribed using the online tool Otranscribe[6]. Only confidential information or irrelevant information was left out of the transcription. The full (Dutch) transcription of all interviews can be found in appendix B.

After the first set of interviews and confirmation of theoretical confidence the framing cycle ended and the augmenting cycle started. This phase was started with a new set of interviews:

1. CGREA portfolio manager office portfolio Utrecht
2. CGREA portfolio manager office portfolio The Hague
3. CGREA portfolio manager office portfolio northern provinces
4. Municipality of The Hague portfolio manager
5. Municipality of The Hague maintenance manager (same interview)
6. National Police coordinator information centre housing

The same method for invitations and introduction was used for the CGREA colleagues. The interviewees from the municipality and the national police where contacted through former CGREA colleagues that were now working for those organisations. The contacts provided were then called to briefly explain the request and plan a meeting. Beforehand and at the start of the interview, permission for a recording was specifically asked. Using the same method described above, the interviews were transcribed.

Including the interview with the coordinating portfolio manager, half of all the CGREA portfolio managers for the office portfolio were interviewed. In selecting the portfolio managers, variety in locations under their influence was also a consideration. Combined with the other two interviews from organisations for reference, this was considered sufficient to prevent bias and be able to supply a variety of voices.

After the final interview, it became clear (even before coding) that virtually all interviews yielded results that where in alignment with the theories found in the literature analysis. Following the principles set by Klein and Myers (1999), that made it possible to proceed to the final step.

3.3.3 Analysis

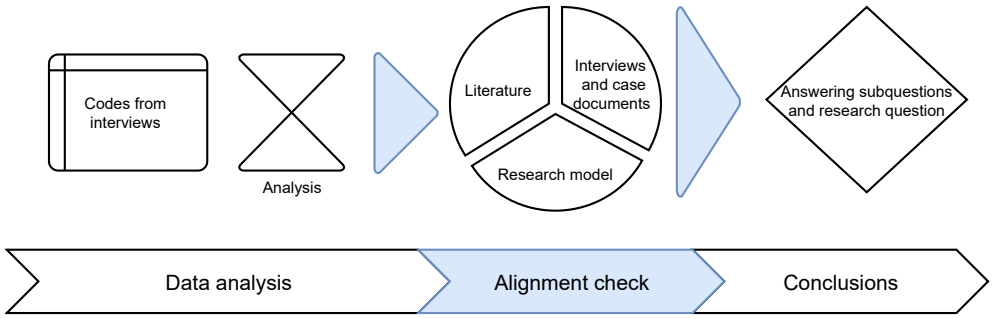

Figure 3.5: Fragment of research process: analysis

To confirm the conclusion that theoretical saturation was reached, selective coding was performed (Glaser, Strauss, & Strutzel, 1968; Corbin & Strauss, 2012). Using Atlas.ti[7], the interview were coded in three phases:

Open coding All interviews, from both the first and second phase, were read through an all relevant lines where coded to summarize the response in that line. This resulted in a total of 79 codes. The codes were applied to the Dutch transcripts, using English codes. The

[6] https://otranscribe.com/
[7] https://atlasti.com/

texts where translated after coding, when writing this report (mainly Chapter 4).

Axial coding All codes were grouped by subject, based on the research questions. This resulted in 10 code groups.

Selective coding The structured codes and the quotes belonging to these codes were analysed to be able both answer the sub-questions and to ensure theory-data-model alignment. The methodology defines this as confirmation of theoretical saturation.

The steps above resulted in the analysis that was ultimately used to answer the sub-questions which in turn where used to form a conclusion based on the main research question. A full overview of the codes and of the data resulting from this analysis are in the next section.

3.4 Details of data analysis

The previous section described the process followed to gather the data for the research. This section provides an overview of the details of the analysis of this data. The goal is to systematically describe the results of each step that ultimately resulted in the answers to the sub-questions in Chapter 4.

3.4.1 Literature analysis

As described in the previous section, the literature was systematically analysed using codes assigned to sections of the research papers. The codes used are visible in Table 3.1. The literature was divided in four groups, based on the three subjects of the research following from the theoretical lens.

Real Estate Management Focus on public real estate management, challenges in real estate management and differences between public and commercial real estate management. Extra attention was given to finding papers that (also) consider public real estate management in The Netherlands.

Big Data Focus on big data implementation, specifically within governments. As with the papers on real estate management, here too research was found that focused on the Dutch government.

Digital real estate Literature that researches digital transformation, data analytics and digitisation within real estate. This is the section of the digital lens focusing on building based data.

Scenarios for data Specific research documents that focus on scenarios for data usage. This to further enhance *digital real estate* code with possible specific examples.

The codes were assigned to the documents. Table 3.2 lists the literature that was analysed and the amount of codes assigned to each document. The relevance of the research to the research topic of this project is reflected in the amount of codes assigned to each document. Based on the literature and the codes, Chapter 2 was written. This to provide a theoretical basis -lens- to focus the interviews.

Real Estate Management	**133**
van der Schaaf - 2002 - Public real estate management challenges for governments	28
Kaganova, Amoils - 2020 - Central government property asset management: a review of international changes	32
Wojewnik-Filipkowska, Rymarzak, Lausberg - 2015 - Current Managerial Topics in Public Real Estate Asset Management	35
Montfort - 2017 - Vastgoed in de publieke sector - de zorg voor doelmatigheid en draagvlak	5
Muczyński, - 2015 - An integrated approach to real estate (porfolio) management	10
Heijer - 2011 - Managing the university campus	21
Heijer et al. - 2019 - Smart campus tools 2.0 exploring the use of real-time space use measurement at universities and organisations	2
Big Data	**89**
Chen, Mao, Liu - 2014 - Big Data: A Survey	4
van Veenstra, Grommé, Djafari - 2020 - The use of public sector data analytics in The Netherlands	24
Tabesh, Mousavidin, Hasani - 2019 - Implementing big data strategies: a managerial perspective	12
Klievink et al. - 2017 - Big data in the public sector: uncertainties and readiness	26
Baig, Shuib, Yadegaridehkordi - 2019 - Big data adoption: state of the art and research challenges	10
Amalina et al. - 2020 - Blending Big Data Analytics: review on challenges and a recent study	13
Digital real estate	**84**
Daniotti, Gianinetto, Della Torre - 2020 - Digital Transformation of the Design, Construction and Management Processes of the Built Environment	13
Burak Gunay, Shen, Newsham - 2019 - Data analytics to improve building performance: A critical review	46
Ladu - 2020 - The Role of City Dashboards in Managing Public Real Estate in Italy: Proposals for a Conceptual Framework	6
Wong, Ge, He - 2018 - Digitisation in facilities management: A literature review and future research directions	6
Ahmed et al. - 2017 - The future of Big Data in facilities management: opportunities and challenges	13
Scenarios for data	**4**
Bouabdallaoui, Lafhaj, Yim, Ducoulombier - 2021 - Predictive maintenance in building facilities: A machine learning-based approachs	2
Konanahalli, Marinelli, Oyedele - 2019 - Drivers and Challenges Associated With the Implementation of Big Data Within U.K. Facilities Management Sector: An Exploratory Factor Analysis Approach	2

Table 3.2: Literature used for theoretic framework and the amount of codes per document exported from MAXQDA

3.4.2 Interview analysis

With the literature and the resulting mindmap, the first three interviews were used to perform a preliminary verification of the main research topics that came from the literature research, as previously described in Section 3.3.2.

During the interviews and transcription afterwards, analysis showed that the interviews confirmed key findings identified in the literature resulting in a further focus for the next interviews.

- Political processes influence public real estate management. Financial considerations are not the primary goal in strategic decisions.
- Decision making in public real estate management is a process that requires information. Information is hard to come by and the quality can be suboptimal. Some information is missed.
- A long-term strategy was created and the aim is to use KPI's. This process is still in development and the impact on strategic real estate management is still unknown.
- Big data analysis is being implemented, using small steps. The challenges identified are largely related to organisational issues and less to technical challenges.
- The data management project also has data from building based systems in scope. Those systems can provide the information that is missed in the present.

The full analysis can be found in Chapter 4. The findings above resulted in a focus for the subsequent interviews, to confirm the emergent model as defined in Section 3.1.1.

The subsequent interviews were used to further test this model. After open coding all the interviews (the first three and the subsequent six), axial codes grouped the codes in subjects. The code groups are represented in Table 3.3. The number of unique codes in each group is visible in the same table .

Code group	Codes
Challenges in strategic real estate management	16
Information required in decision making	16
KPI's or goals	18
Big data readiness	8
Data sources	4
Data usages	6
Public Real Estate Management characteristics	11
Building information used	7
Organisational information used	3
Financial information used	3

Table 3.3: Code groups from the interviews

To further analyse the interviews, they were grouped: the CGREA portfolio managers (4), The Hague and National Police. Tables were then generated for four code groups, based on the emergent model: challenges and goals in strategic decision making, political influence therein and the data used or required. In these tables, the number of occurrences of each code was projected per interview group. This resulted in Tables 3.4, 3.5, 3.6 and 3.7. Because of the focus on decision making, only the interviews about decision making were primarily used.

In the tables, the codes that occurred in every interview, thus in every organisation, were marked and used. The main reason is to ensure the data used was given in all interviews, to prevent so-called dominant voices as defined by the research methodology. The resulting knowledge was used in further confirmation of the model. The theory-data-model alignment was used as a final confirmation of reaching theoretical saturation. This alignment was tested for every sub-question as phrased in Section 1.4.

All information combined was used to write this report: the literature analysis, interview analysis and the documents obtained from the CGREA.

	CGREA Portfolio managers	Municipality The Hague	National Police	Totals
building value	0	1	0	**1**
climate adaptive	2	0	0	**2**
comfort	0	0	0	**0**
energy efficiency	3	1	0	**4**
financial viability	2	1	4	**7**
flexibility	1	0	1	**2**
greenhouse gas emissions	2	0	0	**2**
location	1	0	1	**2**
public value	1	1	0	**2**
quality	1	0	1	**2**
size	1	0	1	**2**
square meters	0	0	1	**1**
sustainability	2	1	1	**4**
sustainable mobility	0	0	0	**0**
uniformity	1	0	0	**1**
user value	1	0	0	**1**
vacancy rate	2	1	0	**3**
vitality	0	0	0	**0**
Totals	**20**	**6**	**10**	**36**

Table 3.4: Codes referring to various KPI's and goals

	CGREA Portfolio managers	Municipality The Hague	National Police	Totals
available space	2	0	0	**2**
data availability	11	2	1	**14**
fragmented strategies	0	2	0	**2**
no insight in building maintenance status	1	0	0	**1**
no insight in building usage	2	0	0	**2**
organisational	0	1	0	**1**
political goals vs real estate goals	3	0	0	**3**
reduce portfolio	0	0	1	**1**
report on KPI	5	0	0	**5**
short term deviaton from long term usage forecast	3	0	0	**3**
strategic ambition vs available finances	2	0	2	**4**
incidental	0	1	0	**1**
no clear strategy	2	1	0	**3**
making the right decisions	2	0	0	**2**
right financial estimates	1	0	0	**1**
Totals	**34**	**7**	**4**	**45**

Table 3.5: Codes referring to challenges

	CGREA Portfolio managers	**Municipality The Hague**	**National Police**	**Totals**
building capacity	8	0	1	**9**
building condition	4	2	4	**10**
building perception	2	0	0	**2**
building performance	1	1	0	**2**
building usage	7	4	2	**13**
building usage forecast	3	1	0	**4**
costs	3	2	2	**7**
costs vs benefits	1	0	1	**2**
energy efficiency	1	2	0	**3**
expected FTE	3	0	1	**4**
failure rate	1	0	1	**2**
gross/net ratio	1	0	0	**1**
maintenance cost	1	0	0	**1**
portfolio availability	3	0	0	**3**
special facilities needed	2	0	0	**2**
user satisfaction	6	0	3	**9**
Totals	**47**	**12**	**15**	**74**

Table 3.6: Codes referring to information required

	CGREA Portfolio managers	**Municipality The Hague**	**National Police**	**Totals**
political influence	12	2	2	**16**
politics not a problem	4	0	2	**6**
politics problem	1	1	0	**2**
Totals	**17**	**3**	**4**	**24**

Table 3.7: Codes referring to political influence

Chapter 4

Results

This chapter starts by describing the details of the case organisation, based on the findings in internal documents, publicly accessible documents and the first set of interviews. After that, the results of the research are presented by answering the sub-questions. This is done using the literature from Chapter 2, the analysis that was described in Chapter 3 and the case information in the sections below.

4.1 Details of the case organisation

To be able to answer the research sub-questions, insight in the various processes in the case organisation is essential. The first part of this chapter contains an overview of the processes and workings of the CGREA, where relevant to the project. This information was gathered from the interviews and internal documents. The information is used in answering the sub-questions later in this chapter.

4.1.1 Housing systems

The portfolio of the CGREA is divided in multiple so-called housing systems ("huisvestingsstelsels" in Dutch) (DGOO, 2011). Each system has its own characteristics.

Each system envelops a subset of the total real estate portfolio, based on the type of building or terrain. As said, each of these systems has different characteristics in terms of who the owner is, who is responsible for daily management, who determines the (policy) conditions for the real estate in the system and who provides the finances. A full overview of the different systems and corresponding characteristics can be seen in Table 4.1.

An example are the defence installations. This is a large portfolio consisting of military bases, military airports, offices, the navy port, etcetera. The owner of this portfolio is not the CGREA, but the Ministry of Defence. Some buildings are rented, so in that case the lessor is the owner. CGREA is responsible for daily management, but the Ministry of Defence sets the conditions and provides the financing. Therefore, strategic real estate choices are not made by the CGREA but by the Ministry of Defence.

The rest of the real estate portfolio is all owned by the CGREA. Except for some buildings that are rented. However, conditions and financing are still different. The Ministry of Justice and Security sets its own conditions for prisons and courthouses. They can decide to build, sell or change this part of the portfolio. They are responsible for providing the needed finances.

4.1.2 Office portfolio

This focus of this research is on the office portfolio. The CGREA is owner of the government offices. Ministries are responsible for financing, but not on a direct basis. Each ministry pays rent for the square meters they have in use. A rental model is a form of new public management that has become popular in the last decades (van der Schaaf, 2002; Wojewnik-Filipkowska et al., 2015). The CGREA has divided the country in 13 regions: 12 provinces and the city of The Hague. Each of these 13 regions has a different square meter rental price. These prices are not determined by the CGREA. The CGREA is a government agency that is not required to make a profit. It is, however, required to manage its own budget and not

	Consists of	Ownership	Management	Conditions	Financing
Defence	Defence installations: terrains and buildings	Defence, lessor	CGREA, lessor, DBFMO	Defence	Defence
Specialties	Prisons, courthouses	CGREA	CGREA, lessor, DBFMO	Ministries	Ministries
Special specialties	Museums, parliament buildings, palaces	CGREA	CGREA	Ministries	Input financing and private rental agreements
Offices	Offices of all ministries	CGREA, lessor	CGREA, lessor, DBFMO	DGOO	Ministries
Terrains	Agricultural terrains	CGREA	Mostly tenant farmers	CGREA	Policy owner

Table 4.1: Overview of the government housings systems (translated) (Rijksvastgoedbedrijf, 2019)

exceed the budget. Therefore, the square meter prices are determined by the costs of this real estate. The CGREA has calculated these prices, but the prices are ratified in a government-wide consultative body which seats representatives of all the ministries (Romanesko, 2014).

Source: rijksvastgoedbedrijf.nl

Figure 4.1: Dutch government offices in The Hague

CGREA is also not responsible for the conditions that apply to the office portfolio. A separate directorate within the Ministry of Internal Affairs and Kingdom Relations, DGOO, sets these conditions: what does a typical government office provide. These are standards like the amount of meeting rooms per square meter, the required size of bike parking places, but also the minimum size a single workplace has to be. The CGREA provides offices based on these conditions.

Strategic decisions for the office portfolio

As was explained in the interviews, DGOO also determines space allocations for all ministries. In practice, this process is managed by the CGREA portfolio managers. The basis for the allocations are so-called masterplans. A masterplan is the projected space allocation within a five year period. Each region has a separate masterplan. The process to create these plans is, in a simplified form, matching the demand with the available offices. Each ministry is asked to forecast the five-year demand: what is your current amount of employees and what growth or decline do you expect? What are further special requirements? Based on the demand, office space is awarded. It is therefore common for buildings to house multiple ministries. The CGREA, for example, is a part of the Ministry of the Interior and Kingdom Relations. The main CGREA office is Korte Voorhout 7 in The Hague, also home of the Ministry of Finance.

The masterplan process is a complex process, as explained by multiple of the portfolio managers involved. It is also a process with a significant financial impact. Based on the masterplans, offices are sold, built, bought and renovated. And because the Dutch government is only interested in large offices in large city centres near public transport hubs, the buildings are often expensive. The masterplans are therefore ultimately put on the agenda of the Dutch parliament to be ratified.

Information is crucial to this process. Information about building availability, capacity, and conditions are among the data that portfolio managers say they use for decision making. The masterplan process is further complicated by political realities. A lot can happen in a five year period, especially in politics. At a minimum, there are elections every four years. Each election is followed by a period where are new government is formed and often new goals are set. New goals lead to changes in ministries, with corresponding changes in the office portfolio. And political influence is also seen in the periods between elections. One example given by a portfolio manager is the problems with earthquakes in the northern

province of Groningen. The cabinet has promised the parliament adequate and swift action. To be able to accommodate this, a whole new government agency was created. This agency grew quickly to several hundred employees, which al had to be based in the centre of Groningen. This "threw the entire masterplan upside down", according to the portfolio manager.

Political influence also means the occasional change in strategy. Formally, when a ministry requires extra space, a location is determined based on availability. Politically, this is not always possible. An example given was the installation of an extra secretary of state by the Ministry of Finance for the so-called "child benefits scandal". A secretary of state want to be near the Minister of Finance and also have all her employees close by. That means space has to be found in a building that could already be filled.

The complexity of the process requires portfolio managers to use all the information available to make better decisions. The impact of this process is big: on government finances but also on real estate especially in city centres. The total amount of square meters that the masterplans envelop is over two million.

Portfolio strategy

In 2019, the CGREA has revised the portfolio strategy in cooperation with DGOO. In this strategy, the long-term goals for the portfolio and the strategic approach to reach these goals has been written down (Rijksvastgoedbedrijf, 2019). The portfolio strategy is established for a period of four years, until 2023, but based on a long-term strategy that is to last until 2030.

Each of the goals has a further explanation about the target for the long term. An example that is relevant for this research is the target for the goal *operations: functional, cost-effective and safe*. In the strategy document, the CGREA acknowledges that housing demand is changing continuously. Government organisations vary in size and the way these organisations work is also subject to change: short term projects with changing numbers of people involved, agile ways of work, etcetera. As stated by the CGREA, this demands buildings and infrastructure that adapt quickly and are able to accommodate both growth and decline without impacting quality (Rijksvastgoedbedrijf, 2019).

Figure 4.2: CGREA portfolio strategy cover

Most of the goals are not aimed toward cost saving. Instead, goals are based on political goals and societal goals. Many require additional investments.

The goals are, as described by portfolio managers in the interviews, mostly in general and often not measurable. This makes it hard to commit to these goals in a project. To this end, the policy advisors are working on key performance indicators (KPI) to determine measurable results for each goal. This is a process that is not yet complete.

4.1.3 Big data initiatives

The CGREA has started multiple initiatives that aim to experiment with data and in some cases data from buildings. Three initiatives are especially relevant for this research project.

Data management project

The goal of the data management project is to "increase the CGREA maturity of data management to a level fitting the CGREA vision" (Pasveer, 2021).

In the interview, the CGREA information manager that participates in this project summarizes that the organisation has to become "more data driven". The project has, according to the same person, defined four types of data. One of these is "data by real estate": coming from building systems.

Smart real estate program

The smart real estate program is a CGREA initiative that was started in the end of 2020. The goal is to enable the use of building generated data (de Kruijff, 2020).

This project is executed primarily as a contribution to this program and to research the impact data can have on one of the strategic real estate processes of the CGREA.

Dashboard of De Resident

Source: rijksvastgoedbedrijf.nl

Figure 4.3: *De Resident* - Home to two ministries

In 2019, a pilot initiative was undertaken within the CGREA. The goal of this initiative was to experiment with data from building systems.

To this end, a trainee with a master's degree in data science was provided with data from various building systems from a single office building. This building, called De Resident, is located in the centre of The Hague. It can be seen in Figure 4.3. It is the main seat of two ministries: the Ministry of Social Affairs and Employment and the Ministry of Health, Welfare and Sport.

The data used in this project came from offline datasets with raw data from various building automation systems. The data was imported in PowerBI and visualized in specially created dashboards. Each dataset provided one or multiple sources of information. An overview of the data sources used is seen in Table 4.2.

Data source	Data provided
Building automation system	CO_2 sensor data from meeting rooms
	Temperature readings from sensors in rooms
	Manual temperature adjustments from rooms
Access control system	Entry and exit time for every individual (anonimized)
	Location of entry and exit
Energy meters	Energy usage
Facility management information system	Reservations for meeting rooms

Table 4.2: Data sources used in the 2019 pilot

While creating the dashboards, interviews where carried out with various specialists to give meaning to the data and to check the potential of the dashboards (van Kempen, 2020). Screenshots from the dashboard are provided in appendix D. One of these dashboards gives insight in occupancy. In government office buildings, every individual has to enter or exit the building using their access card. This data is stored in the access control system. This system can therefore provide continuous insight about the amount of people in the building. In the dashboard, the data is visualized in a fourteen month period. The dashboard showed that the average occupancy of this building was significantly lower on Wednesdays and Fridays (the green and yellow line) than on the other days of the work week. Summer and winter holidays are also distinguishable. The bars on the lower left indicate the average working hours on the day, showing what time most people enter and exit the building, in average. This dashboard, although being experimental, was actually used to show that the occupancy never exceeded the maximum amount of allowed occupants from the fire permit. There were doubts about this because the amount of people theoretically housed in the building exceeded that number.

Another dashboard combines the occupancy data with the data from the energy meter. The point cloud visualises the amount of people in the building in relation to the energy usage. The conclusion that can be drawn here is that, while there is a small increase in energy with higher occupancy numbers, the energy usage does not have a direct relation with the occupancy. What also was an insight that raised questions with technical specialist is the high energy usage in weekends.

4.1.4 Summary of findings from the case organisation

The sections above provide information about the processes around strategic decision making at the CGREA. Each housing system gives different levels of control to the CGREA. In the case of the office portfolio, this control is most direct. Strategic decisions about when to buy, divest, transform or build

offices are primarily made within the CGREA. Beside that, there is a portfolio strategy that also contains information about decisions made on a strategic level.

On the other hand, the CGREA has ventured into the subject of big data. Programs are started to use data from various sources to benefit multiple processes in the organisation. These programs are still in the early stages and have yet to generate data that is used in decision making. A pilot was undertaken that has demonstrated the potential of some of this data.

This information, combined with the information from the interviews and the literature analysis, is used to answer each of the sub-questions for this project. This is the following section, where each sub-question is answered individually.

4.2 Sub-questions answered

The results in this section are presented by answering the research sub-questions. This is done using a brief summary of the findings of the literature analysis (Chapter 2), the case details in the previous section and the selective coding of the interviews with decision makers. The theory-data-model alignment is verified using the three questions referred to in Chapter 3:

Theory-data alignment	"Can the case data be explained by existing theories?"
Data-model alignment	"Does the data support the emergent model?"
Theory-model alignment	"Do existing theories support the emergent model?"

The model used is based on the hypothesis (see Section 1.4): Data from building systems can be defined as big data and therefore can be used to provide information that is not currently available and can be used for decision making in strategic public real estate management processes.

4.2.1 SQ1: What is the difference between public real estate management and commercial real estate management?

Literature

Real estate management goals are the same in government and commercial organisations. Real estate has to support the demand of the organisations. Those demands are changing continuously, so continuous management is necessary. Over the years, the importance of real estate as a strategic asset to organisations has steadily grown, leading to a growth in resources for strategic decision making. When to buy, divest or transform the portfolio are decisions made on a strategic level. This process is the same for both commercial and public organisations. (Literature Section 2.2.1).

The difference is in the stakeholders and therefore different goals. Government real estate is being accounted by not only financial goals, but also political and societal. And with this, the political goals often supersede the financial goals. And with political goals changing based on society, elections and worldwide developments, the goals for real estate can also change frequently. (Literature Section 2.2.2).

So, according to literature, there is a difference between the two. Both are a management process requiring decision making, but political influence and much less focus on financials is a difference.

Case findings

As can be seen in the case background description in Section 4.1, the CGREA has a strategic management process that is aimed for effective management of the real estate portfolio. The same is the case for the National Police and the Municipality of The Hague. Every organisation has a dedicated department for strategic real estate management and invests significantly in the portfolio to match it to the organisational demand. The interviews also confirmed that finances are not the primary goal. Several interviewees commented on this:

CGREA policy advisor real estate strategy:

> "But we really don't control based on finances."

CGREA coordinating portfolio manager:

> "Financials are in reality just a result."

CGREA portfolio manager office portfolio Utrecht:

> "We don't control based on financial return."

National Police:

> "'How can it be that I don't get a clandestine premise while I really have to observe those guys?' [...] As the PDC you can't respond with: 'that's not possible. It's too expensive.' Those guys just have a demand en we are just going to make it. Just saying."

Municipality of The Hague:

> "Real estate is on the agenda, but, talking from my own background too of course, not in a way like it will be at an investor or a commercial real estate developer. [...] Even just the fact that you own a billion in capital you will have to explain someday."

However, as seen in Table 3.4, financial viability is one of two goals that all respondents have cited. So while finances are not the primary goal, they do play a role in every organisation's decisions. But this is more out of justification, for example as quoted by the CGREA coordinating portfolio manager:

> "In general: everybody has to have a roof over his head without it being too expensive or without use implementing golden taps."

Or as a result of a political directive, as was the case for the National Police costs savings were demanded as a result of the forming of the National Police (see Section 1.1.3). But even here this financial directive often is superseded by organisational demand as seen in the quote above. The political influence is recognised in all organisations. The example from given in Section 2.2.2 was confirmed in the interview with the CGREA coordinating portfolio manager:

> "So three years ago we were given a directive to cut budgets, so we divested real estate. That was not all doom and gloom: we also had the chance to handle our real estate more smart and efficient. But that was pushed so far that we effectively landed too hard a year ago because we divested so much that we were still doing it [...] but meanwhile the ministries were growing again. So the mismatch between supply and demand went awry so fast that it became clear we divested too much. We knew that in advance. We knew: you must not divest so much real estate, you always need fat on the bones. But the political assignment was different."

Political influence as opposed to "rational decisions" was confirmed in other interviews too:

Municipality of The Hague:

> "That was very much directed, also from the policial side."

CGREA portfolio manager office portfolio northern provinces:

> "Politicians for example decide there has to be more attention for child benefits."

Or the National Police, responding to the question where the goals for sustainability came from:

> "Directed from the central government."

All in all, policital influence resulted in a total of 16 occurrences of the political influence code in the interviews, with occurrences in all separate organisations.

Answer and alignment

The difference between public real estate management and commercial real estate management is the fact that in the first, politics has a significant influence on decision making. Financial viability is only in play when it is a political goal or as a final check on.

To check alignment: the case data, both from case documents as the interviews, support the theories found in literature. Since, according to the literature, real estate management is a decision making process, decision making referred to in the model is necessary. Finally, the data also confirms that continuously decisions are made in strategic public real estate management about buying, divesting and transforming. This is the case for the CGREA, but also for the National Police and the Municipality of The Hague. This all confirms theory-model-data alignment.

4.2.2 SQ2: What is the definition of big data and is this applicable to building based data?

Literature

The definition of big data in literature varies, based on the amount of characteristics that are applied to it. The base characteristics always apply: volume, velocity and variety. There is a lot of data (*volume*), it is (near) real-time (*velocity*) and there are different types of data from different sources, that are combined (*variety*). (Literature Section 2.1.1 and Section 2.3.2).

Case findings

Looking at the case data, two sources are used to verify if the definition is applicable. The first one is the dashboard described in Section 4.1.3. To build this dashboard, datasets from the building based systems were used. The sources are listed in Table 4.3.

Data source	Data period	Data points	Timeliness
Access control system	14 months	3,028,377	event (every card swipe)
Building automation system	half year	8,520,624	hourly
Energy meter	one year	9,408	hourly

Table 4.3: Data sources from De Resident in period, amount and timeliness

When matching this data to the three V's in the definition, the following can be defined:

Volume: three data sources with a limited timeframe yield almost eleven million data points. This is a high volume of data to analyse.

Velocity: for this dashboard, to limit the amount of data used, only hourly building automation system values were used. And for a limit number of floors. The BAS had the possibility to output five minute data values. This fits the definition of near real-time. All events from the access control system are logged, so this is real time. The energy meter values are only logged every hour. But this is because the energy management system the CGREA uses stores data from all buildings. To limit the amount, no real-time values but only hourly values are chosen.

Variety: the fact that these three data sources were used, means there is variety in the data. Every source came required different processing to be able to use it in the dashboard.

Considering the above, the data can be considered big data according to the base definition. And with that in mind that for the CGREA, this is only one of thousands of buildings, with all the same amount of data.

Based on the interview with the CGREA information manager, confirmations of the previous conclusion can be found. When asked about the comparability to big data, after first confirming that the interviewee knew the definition, his response was:

> "Those energy data are fifteen-minute values, so if you have fifteen-minute values of the gas meter of a building, or of the electricity meter, then you are talking about significant data fields. Although I think that by the big data the definition they mean that you have fifteen-minute values of hundreds of buildings, for example. But those are the amounts where energy management is working with."

This further underlines the conclusion about the volume and velocity. For variety, the processing required was briefly touched in another response in the same interview when asked if the tooling used was aimed for big data:

> "Yes. Even though it could be the case that what is now done with energy management could also be done with Excel. But that is not tried because the people that perform those analyses can work with applications like R and Python."

Answer and alignment

The answer to this question is yes: both literature and the case prove that building based data can be defined as big data, as described above.

To check alignment: the case data, both from case documents as the interviews, support the theories found in literature as is also described above. Because of this, the data also supports the model that states that it can be defined as big data. The literature further underlines this by providing an overview of research on big data analytics on building based data. For this sub-question, the theory-model-data alignment is also confirmed.

4.2.3 SQ3: What challenges are found for decision making in strategic real estate management?

Literature

Strategic real estate management according to the literature has to, ultimately, fulfil the requirement of continual adjustment. Adjustment to the goals of the organisation and the users. The decisions made aim to adopt the best possible solutions to these changing requirements: by making predictions, collecting data and creating future references. Considering the stakeholders that are defined in public real estate management: users, finance and the government. The literature lists numerous challenges in making these decisions, as previously shown in Table 2.2. (Literature Section 2.2.3).

Case findings

Based on coding, 15 challenges were found in the various interviews with decision makers. The overview was previously given in Table 3.5. Many are comparable to the ones listed in Table 2.2. There is one challenge that is named in all three organisations and is also referred to far more than all other challenges: data availability. This is also one of the challenges defined in literature.

Most interviewees cited the lack of data or information as one of the major challenges in making the right decisions. For example the Municipality of The Hague:

> "We are, sort of, back to square one. If you put it on a distance it is indeed a risk that you have less control. Have less information. Control less. As far as I know [...] we have to gain more control about the supply in The Hague to better facilitate the shortages there are on many areas, the questions there are on many areas. That information is there for a part and for another part it is fragmented."

And for the National Police:

> "ou can see that our current information position on our objects, on the subject of quality let's say, has improved. So we use more in investigations and business cases that we do for a project. So an operational unit comes with a question like: 'can I store stuff there?' or: 'Can we move that station?'. Then an investigation is held and, now more than ten years ago, maintenance data is used more. So that's going in the right direction, let's say."

And also for the CGREA, multiple portfolio managers cited information as a challenge. CGREA coordinating portfolio manager:

> "So there is a big building, we know how many square meters it is but we don't always know how many workplaces there are."

CGREA portfolio manager office portfolio Utrecht

> "Right now, I don't even know if one building required more maintenance than usual or more maintenance as opposed to the other building."

CGREA portfolio manager office portfolio northern provinces:

> "But apparently it is hard to get the status quo of buildings in the case of existing buildings."

> "And also what has been invested in a building in the past, that is also not always traceable in the administration."

CGREA portfolio manager office portfolio The Hague:

> "We have the masterplans but that is, well, the information in those: I wonder how accurate that all is. You often see difference in what's in one database and what's in te other database. Somewhere there's talk of 60,000 square meters for building X. And in another daabase you

> see 65,000 square meter. Allright: now what should I believe? Is it that one or that one? That accuracy of information but especially also the accessability, centralising it. That is something that would be a huge help for me."

Information issues were also a major reason to start the data management project, as cited by the CGREA information manager:

> "Data management started a few years back. Ultimately, the reason for that was the very bad quality of data."

Answer and alignment

In making strategic decisions for public real estate management, many challenges are found, in literature but also based on the interviews. The challenge identified by all organisations and also by every CGREA decision maker, is the availability and quality of information. Decision making is heavily dependant on information. For Dutch public real estate, the decisions that are made have significant impact. This is the reason that, according to the CGREA coordinating portfolio manager, these strategic decisions are kept confidential and are ultimately sent for approval to the Dutch parliament. The interviews made clear that information is a key requirement for this process.

Literature		In case?	Codes
Strategy problems	Fragmented	**Yes**	2
	Incidental	**Yes**	1
	Reactive	No	
	No clear strategy	**Yes**	3
Portfolio problems	Data unavailable	**Yes**	14
	Data outdated	No	
	Managed by budget most of the times	No	
	Underutilized properties	No	
Finance problems	Ad hoc political decisions	**Yes**	3
	Lack of risk management	No	
	No reliable data to determine fair rents	No	
Technological problems	Shift from asset-intensive to information-intensive	No	
	Implementation of modern IT tools	No	
	Managed by multiple entities	No	

Table 4.4: Challenges from literature mapped to challenges from interviews

To check alignment for this sub-question: the challenges defined in literature and from the interviews are not a one-to-one match. To illustrate this, both are represented in table 4.4. That can be explained because in literature, cases not only in The Netherlands were researched but also other countries with different types of public real estate management. However, there is a clear overlap between some challenges: data availability and quality, political decisions and fragmented, incidental or unclear strategies. For this, there is sufficient alignment.

The model states that information can be used. Both literature and the case underline information (data) as a requirement and unavailable data as a problem. This is the presumption of the model, that data can be beneficial to the process. Since this is the case, there is alignment for theory and data. This confirms theory-model-data alignment.

4.2.4 SQ4: What information is required for these decisions?

Literature

The literature reviewed does not explain in detail what information is used in making strategic decisions, other than in general. For example supply and demand (literature Section 2.2.3). Literature does provide multiple KPI's that used in decision making (literature Section 2.3.3). Those KPI's require insights, as seen in Table 2.3 in Chapter 2. These can be translated to a list of required information:

Building capacity: floor space used per FTE and the percentage of free space.

Building performance: energy effiency, indoor environment quality and greenhouse gas emissions. Both for sustainability and comfort.

Building condition:	to determine the quality of the building and to decide if renovations are necessary, now or in the future.
Customer satisfaction:	to measure the quality of the building but also if demands are met.
Financial information:	primarily the cost to maintain the building and the management costs.

Case findings

The process that is responsible for strategic real estate management is called *Manage real estate portfolio* (Rijksvastgoedbedrijf, 2017). The CGREA employs an online tool to describe the various business processes. Under the main process, there is a process called *Compose master plans offices*. The description contains the following (translated from Dutch):

> The data received from process *data requisition office master plans at DGOO* are used by the portfolio manager in the "master plan calculation model". With this model multiple scenarios are assessed and calculated. Additional investigations, business cases for parts of the region, analyses or calculations can be attributed to gain more insight in proposed mutations.

The data requisition process, as referred to in the previous description, contains:

> Periodically the office master plans are brought up to date. For this end, the office demand is requested from the ministries (number of FTE per regio including additional demands). In this processtep the CGREA requests the need at DGOO. If the change impacts a limited number of buildings, the decision is made through a request for change (RFC). Complete master plan actualisations are done periodically, as decided with the minister of Interior Affairs and Kingdom Relations or provisional when there are causes that affect the entire portfolio. Causes for a complete master plan actualisation can be:
> - Changes in demand development
> - Developments in policy
> - Developments in the market
> - Amount of RFC's

Finally, there is another process called *request additional information for master plans*:

> Before the portfolio manager draws up alternatives for actualising a master plan, he first collects additional information that is of interest. This is among others:
> - Information about value development
> - Information about sustainability development
> - Information from the policiy letter [...] from DGOO [...]
> - CGREA Portfolio strategy

According to the official process descriptions, information is needed in the process and according to the process descriptions, the portfolio manager is the central actor to gather and use that information.

Table 4.5 lists all the information sources that were given in the interviews. The lines in color indicate information sources that are mentioned in most interviews across most or all organisations. The information cited most and in all interviews is building usage. Usage forecast is also cited, either explicitly or as FTE forecast. Building condition and capacity were also characteristics mentioned in most interviews. And finally, user satisfaction.

CGREA coordinating portfolio manager:

> "So I really have a need for that information: how many workplaces are there?"
>
> "Complaints are expected. For example: it is too busy or the toilets are always occupied. Or the restaurant is occupied. You want to be able to anticipate on that."

CGREA portfolio manager office portfolio Utrecht:

> "Ultimately all sorts of information that says something about the quality of the building and the building usage: [...] amount of workplaces in relation to the size of the building."
>
> "So I find personally that user satisfaction is a really important measurement."

	The Hague	Coordinating Portfolio Manager	Portfolio manager Utrecht	Portfolio manager northern provinces	Portfolio manager The Hague	National Police	Totals
building capacity	0	3	2	0	3	1	**9**
building condition	2	0	2	1	1	4	**10**
building perception	0	0	1	0	1	0	**2**
building performance	1	0	1	0	0	0	**2**
building usage	4	1	2	1	3	2	**13**
building usage forecast	1	1	1	1	0	0	**4**
costs	2	2	1	0	0	2	**7**
costs vs benefits	0	0	1	0	0	1	**2**
energy efficiency	2	0	1	0	0	0	**3**
expected FTE	0	0	0	1	2	1	**4**
failure rate	0	0	1	0	0	1	**2**
gross/net ratio	0	0	1	0	0	0	**1**
maintenance cost	0	0	1	0	0	0	**1**
portfolio availability	0	1	0	0	2	0	**3**
special facilities needed	0	1	0	0	1	0	**2**
user satisfaction	0	2	3	0	1	3	**9**
Totals	**12**	**11**	**18**	**4**	**14**	**15**	**74**

Table 4.5: Information requirements per interviewee

CGREA portfolio manager office portfolio The Hague:

> "On the other side is our own real estate information. The supply we have. What does it consist of, how many buildings, how many square meters, what is the condition, the technical state of it."

National Police:

> "We can say, thats about the quality of the building, it can house that much FTE."

> "How do the teams in a building experience it? [...] we now try to add more qualitative figures to that: appreciation numbers. And for that we just have to do yearly interviews, for example. Or take surveys with the users of the buildings"

The Hague:

> "The available information of the buildings. The state of maintenance. Exploitation information."

CGREA portfolio manager office portfolio northern provinces:

> "But it is evidently hard to get the status quo of existing buildings, in practice."

As seen in Table 4.5, the information cited most is building usage. All interviewees mentioned this information requirement. Usage is different from building capacity. Capacity is the statistical information about the theoretical number of people and facilities could house. Usage is a statistic about the actual number of people. When asked in general what information is missed, this was often the first response.

CGREA coordinating portfolio manager:

> "So I really have a need for that information: how many workplaces are there? But also: how many people are in the building on a daily basis? Are there peak days, are there off-peak days? Or are there peak hours and off-peak hours? Everyone can imagine it: the morning and evening are peak moments and the Tuesday and Thursday aer also peak moments. But I still want to know beter and beter spread throughout the day. Beter spread through wings. So you have more insight in the way a building lives. En how there is lived in it. Why I find that important? To be able to control more sharply between supply and demand."

CGREA portfolio manager office portfolio Utrecht:

> "So indeed, occupancy rate. You can derive something from that the moment an urgent demand comes: where is available space or not. Look, we now only know: we rented the square meters. But you don't know if those square meters are actually used."

CGREA portfolio manager office portfolio northern provinces:

> "To gain insight in actual workplace occupancy. Everybody says we have that many FTE en we are in the office a lot. We hire additional companies to train our people and it's always busy. And sometimes you notice that our contacts don't even really know that well how busy it is. Because the facility provider supplies you with other information for example: more space is needed, while in practice the meeting rooms are not busy at all. So ultimately the factual workplace occupancy, that would be a very good one to at least start the discussion about those RFC's. Is it really necessary or can you use the available space differently?"

CGREA portfolio manager office portfolio The Hague:

> "I would, for example, like to have information about the occupancy of different buildings. There is a lot of complaining about the building being too full, for example, to name something. I am curious if that's really the case. I would like to have information about that."

National Police:

> "And what is requested more than ever these days is data about, say, the use of objects. So real occupancy rates and such. So that took off like: that building has a capacity of X workplaces and how many do actually come?"

The Hague:

> "What about usage? Is it used in the right way? Control based on sustainability, energy use, that can be improved. Next to that I, also think, but then you're dependant on the systems in a building. Nowadays there are systems with meshes and all that provide a lot of information and data about workplace usage, for example. Use of rooms, climate-related cased, CO_2 measurements and such. So you can monitor the real usage, the daily usage of a building."

Answer and alignment

The information needed for strategic real estate management can be surmised as supply and demand: what is needed and what is available. The demand is primarily based on FTE and possible special needs. The supply is based on square meters. Important information to judge the supply is the condition a building is in: when is a renovation needed? How long can it be used? Costs, although previously identified as not being a primary goal in public real estate management, is cited as an important boundary.

Information that is missed as described above, is information about the actual usage of a building. What are the occupancy rates? How is the building used in practice as a contrast to the theory? And to a lesser degree user satisfaction: when complaints are present, investigations are done. But that is primarily as a reaction to that complaint. Interviews are periodically used to measure satisfaction, as mentioned by an interviewee.

The theory and data are in alignment: there is overlap between the information cited in the literature and the information cited in the interviews. Most information mentioned in literature and defined in the beginning of this section was found in the interviews and in the process descriptions. Building capacity and condition are the most obvious ones. The model assumes not all information is available. That is confirmed in the interviews, especially for building usage information. That information is currently unavailable but wanted by all interviewees. Literature confirms that information accuracy and availability are common problems, supporting the model. This confirms the total alignment.

4.2.5 SQ5: What building data is available?

Literature

Many building-based systems are controlled by regular IT hardware and software. Most of these systems use data in one form or another to fulfil their task. Even though that data is not primarily intended for

analysis, it can be used as such, when processed and used in specific tooling. Literature gives an overview of many systems that can exist in buildings. There is a distinction between established data sources: data from systems already controlled by the property owner, and emerging data sources: systems from possible different organisational sources. An overview is provided in Table 4.6. (Literature Section 2.3.1).

Emerging data sources		**Established data sources**	
System	**Information**	**System**	**Information**
Access	Badge in/out	BAS	Temperature, CO_2, etc.
Security	People counts by cameras	Lighting	Light sensors, etc.
CMMS	Complaints	Meter	Energy meters
	HVAC failures		Gas meters
IT	Number of wifi devices		
HR	Performance		
	Satisfaction		

Table 4.6: Emerging and established data sources present in buildings

Case findings

Most government buildings employ building based systems. There are a few exceptions when it comes to very small properties, but that is a tiny subset of the portfolio. All offices that are part of the master plans employ building based systems. Not all systems are owned and controlled by the CGREA. Ownership is arranged in the *division of roles and tasks* (Rijksvastgoedbedrijf, 2017) that was established in 2016. In 2017, a product and services catalogue for building-based IT was established by DGOO (DGOO, 2017). In this document the IT systems in buildings are described and the responsibility assigned to either the CGREA or government IT suppliers.

Systems present are:

- Building automation systems (BAS) to control heating, ventilation, air conditioning and cooling (HVAC) and in some cases also lighting. These systems are owned by CGREA.
- Security systems with access control and cameras. The security policy in government offices is that everybody enters and exit with his or her personal access card. This is enforced with turnstiles. These systems are owned by CGREA.
- Meters for energy and gas, sometimes only one per building, sometimes also multiple meters for different parts of the building. These systems are owned by CGREA.
- WiFi for providing wireless internet access. These systems are owned by the IT suppliers.
- Contact with the users of buildings, frequently mentioned in interviews, usually goes via the facility providers. These employ systems to log complaints and arrange the booking of meeting rooms (FMIS).
- The government employs a organisation-wide HR system. Privacy concerns are expected to be a difficulty in using data from this system.

These systems are comparable with the systems in literature, as can be seen in Table 4.7.

Type	**Literature**	**Case presence**	**Owned**
Emerging	Access	In every building, individual access	Yes
	Security	Cameras and sensors in most buildings	Yes
	CMMS	FMIS systems to register complaints and room reservations	No
	IT	WIFI in buildings	No
	HR	Government-wide HR system	No
Established	BAS	BAS in every building	Yes
	Lighting	In some cases via BAS	Yes
	Meter	Electricity, water and gas usage in every building	Yes

Table 4.7: Data sources from literature compared to the case organisation

The *De Resident* pilot (Section 4.1.3) has used multiple sets of data from the list above: access control data, meeting room reservations, BAS data and meter data. The data is available and can be exported for further analysis. This is not only the case for this building, but also for other buildings in the portfolio. As told by the CGREA information manager in the interview, *data by buildings* is one of the four data sources targeted with the CGREA data project. Access control and BAS data are both mentioned in the same interview.

CGREA is not the only organisation to employ these systems. The Municipality of The Hague ("Off course we employ building automation systems") and the National Police ("data from our BAS") both have them, as is customary in almost all corporate real estate.

Answer and alignment

Building based systems in direct control of the CGREA are the building automation system, security and access control system and meters. These are present in all offices. Other systems (wifi, HR, FMIS) are present but not in control of the CGREA. See also Table 4.7.

As seen above, systems listed in the literature are also found in the CGREA buildings. The model presumes building data to be present, which is confirmed bot in literature as in the case data. This confirms full alignment.

4.2.6 SQ6: Can building data provide the required information?

Literature

Literature lists many possible uses for building based data. However, research is mainly focused on using data to improve the systems and daily management in the building itself. Data is used to measure the performance of the systems, to prevent and reduce failures and to optimize HVAC. Reduction of energy and improvement of building systems is to increase the sustainability of buildings. (Literature Section 2.3.1).

Using this data to make strategic decisions is not a topic that has been researched yet. Implicitly, literature does cite the possible insights this data can give: occupancy rates, user satisfaction (sometimes from third party systems) and insight in failure rates. The latter could provide insights in the condition of the building systems. (Literature Section 2.3.1).

Case findings

The dashboard of *De Resident* has used the access control data to provide an historic insight into the occupancy of the building. These access control systems are deployed throughout the government portfolio, leading to the conclusion that the data can provide the same insight in all buildings, as long as every individual has to enter and exit with a card. As said, because of government-wide security policies, this is the case. Data from the building automation system, for example temperature or CO_2 can provide extra information when climate complaints are received. And what was also monitored was the reservations matched to CO_2 levels in a meeting room: did the level rise when a meeting room was booked, or not? This could tell something about the actual use of the room.

But mainly, the occupancy rate that can be visualized is what was mentioned in the interviews as a missed piece of information. The data provided for the pilot also contained the department information for each swipe, making it possible to further refine the information and show the occupancy per organisation or even department.

Access control systems were also mentioned in interviews as data source to provide that information:

CGREA Information manager, when asked about the systems targeted for future data analysis:

> "Yes, next to energy meters those are building automation systems, access control systems. Those are the major ones."

CGREA portfolio manager office portfolio The Hague:

> "Ideally, you have a certain technique that measures non-stop, year-round. And I think that's easily done because in all building you only gain entry with a card. So install a counter on it and you have that information."

Answer and alignment

The answer is yes: building based data can provide at least one piece of missing information: occupancy rates. This is confirmed by literature: badge in/out from Table 4.6 and in the case by the occupancy dashboard from De Resident based on that badge information, see Section 4.1.3. Other information may also be possible but requires further research.

Both in literature and in the case, the information generated is found, albeit that in literature the use is as described above, different from the intended use in te case. The model further states that the building systems provide information that is currently not available. Existing theories do research usages for data that are new, but not for the specific usage in the model. That makes alignment not complete, but because this is the main focus for this research project, it is understandable that no theories exist yet. The data is in alignment with the model, because the data confirms that there is unused information that can provide the information.

4.2.7 SQ7: Can this data be used in public real estate management?

Literature

To answer this question, two questions are important: can big data be used? And can objective data be used in a climate where politics also influences decision making? Both topics are found in research on big data implementation in the public sector. (Literature Section 2.1.2).

The quadrants listen in Table 2.1 provide information. It is not disputed that big data can be used, instead four perspectives with a different impact each are given. So, according to this, the data is beneficial, it just depends on the way it is used in the political context. This is important, because the political context is what separates public real estate management from commercial real estate management. Ad-hoc political decisions are, according to literature, one of the challenges decisions makers have to deal with.

The second challenge identified in literature is the low implementation rate of big data strategies in government. This is mainly not a technical issue, but a organisational issue. Insight in additional objective information requires an organisation that can support that new information.

Case findings

The data management project is the initiative within the CGREA to make use of big data. Not only from building based systems, also from other sources. The project plan lists four goals for the current phase:

1. RVB has a vision on data: the current and wanted position around data management are mapped.
2. Data governance has been arranged: the CGREA ensures availability of correct and consistent data for the CGREA.
3. Data is accessible from a central location: associated services are available.
4. Data usage provides demonstrable value for the CGREA: the value creation of data analysis and visualisation for the CGREA primary processes has been demonstrated.

The goals above are not exactly measurable, as no measurable goal is provided. A strategy to ensure data usage in the primary processes is not a goal per se. However, the project plan also mentions that implementation in the business processes is a task for the organisational units itself and not the project. The project only provides the tools. The interview with the CGREA information manager provides some additional insight:

> "From data management we now try to get the organisation ready to deal with that [data analysis]"

and, when asked what the main problems in implementing a data strategy are:

> "Maybe the culture is the greatest. The culture to do stuff measurably instead of on a gut feeling. It's already hard if you have always had to decide based on gut feeling because you never had supporting data. En now you have to make decisions where your gut says you must not. In the beginning you can say: the data quality must not be sufficient so I can still do

what I think is right. But the more you work with data, the more that data quality will rise. Then there comes a point where you can no longer dismiss it."

The same question was asked in the interviews: do you think measurable data will be useful in a political context?

National Police:

"Yes, and that's where I'm going, where it's financial or meter driven. Those are for now important indicators where we want to realise our real estate portfolio with. We have to reduce square meters and Euros."

CGREA coordinating portfolio manager:

"We act in a political context and if we don't have the data as a support we are behind 1 to 0. And so then there is a user who says on a high level: /textquotewe are short in space, my people are unhappy. Dear CGREA you are there to facilitate us, are you not?. And if we then say: 'Yes, uhm, yes, that could be the case but we don't exactly know'. Then your behind 1 to 0. You are so much firm in the conversation if you can support it with hard data."

CGREA portfolio manager office portfolio Utrecht:

"I am search where that's going to bite because I think the data can also support us better housing our users. So I would not immediately know where that's going to, say, cause problems."

CGREA portfolio manager office portfolio northern provinces:

"I think that always helps. Not that the demand will change, because if politics says they have a problem with child support and that has to be handled so we go full swing for that. Extra people have to be hired and those have to be able to work. [...] then you can have the right discussion."

"Sure. Even if it is just to have the discussion with the users. If they say: we are tight. Then you can show if that's really the case."

The Hague, after explaining a scenario for data:

"Yes, that makes the conversation much easier."

Answer and alignment

The answer to this sub-question is twofold: the data is usable according to the decision makers. However, an important challenge identified by literature -organisational changes required- are not explicitly targeted in the data management project. When looking at the four perspectives that impact decision making, as seen in the literature (Section 2.1.4), the scenario described by the interviewees can be fitted best in quadrant 3: politics of algorithms. This means that the decision makers in this case are not really in the role of the decision makers, but in the role of data suppliers. They can better influence outcomes by providing information to the key players higher in the organisation and influence the decisions.

The data and the theory are in alignment: both theory and the case cite organisational challenges as the major obstacles for data strategies. And in both literature as the case the conclusion is that big data is useable in a political environment. Since the model also assumes the data can be used in the decision making process, this is essentially supported by the same conclusions. This results in full alignment.

4.3 Overview of results

The previous section has answered all the sub-questions. This was done by explaining the answer according to literature and provide the answer from the case data: documents and interviews. Alignment was confirmed for each answer, to ensure the theory-model-data alignment. An overview of these answers is below.

SQ1: What is the difference between public real estate management and commercial real estate management?
The difference between public real estate management and commercial real estate management is the

fact that in the first, politics has a significant influence on decision making. Financial viability is only in play when it is a political goal or as a final check.

SQ2: What is the definition of big data and is this applicable to building based data?
The definition of big data is that it is, at minimal, voluminous, (near) real-time and varied. Building based data matches this definition.

SQ3: What challenges are found for decision making in strategic real estate management?
The greatest challenge is the availability and quality of information. Decision making is heavily dependant on information. For Dutch public real estate, the decisions that are made have significant impact. This is the reason that these strategic decisions are kept confidential and are ultimately sent for approval to the Dutch parliament. Information is a key requirement for this process.

SQ4: What information is required for these decisions?
The information needed for strategic real estate management can be surmised as supply and demand: what is needed and what is available. The demand is primarily based on FTE forecasting and possible special needs. The supply is based on square meters available. Important information to judge the supply is the condition a building is in: when is a renovation needed? How long can it be used? Costs, although previously identified as not being a primary goal in public real estate management, is cited as an important boundary.

Information that is missed is information about the actual usage of a building. What are the occupancy rates? How is the building used in practice as a contrast to the theory? And to a lesser degree user satisfaction: when complaints are present, investigations are done. But that is primarily as a reaction to that complaint. Interviews are periodically used to measure satisfaction.

SQ5: What building data is available?
Building based systems in direct control of the CGREA are the building automation system, security and access control system and meters. These are present in all offices. Other systems (wifi, HR, FMIS) are present but not in control of the CGREA.

SQ6: Can building data provide the required information?
Yes, building based data can provide at least one piece of missing information: occupancy rates. Other information may also be possible but requires further research

SQ7: Can this data be used in public real estate management?
The answer to the question is twofold: the data is usable according to the decision makers. However, an important challenge identified by literature -organisational changes required- are not explicitly targeted in the data management project. When looking at the four perspectives that impact decision making, as seen in the literature, the scenario described by the interviewees can be fitted best in quadrant 3: politics of algorithms. This means that the decision makers in this case are not really in the role of the decision makers, but in the role of data suppliers. They can better influence outcomes by providing information to the key players higher in the organisation and influence the decisions.

Chapter 5

Conclusion and discussion

5.1 Conclusion

The goal of this project was to answer the following question:

> "To what extent can building based big data contribute to strategic decision making in Dutch public real estate management?"

The answer to this question, based on the results in Chapter 4, is that to a certain extent, this is certainly the case. The strategic decisions that have significant impact on the real estate portfolio -when to buy, divest or transform- are very information-heavy. This information is not always available. And if it is available, it is not always of sufficient quality.

The impact of the decisions made are significant. Buying or transforming real estate has a financial impact. The CGREA turnover in 2021 was 1,3 billion Euro. For the National Police, 2021 housing costs were 313 million Euro (Ministerie van Financiën, 2020). As explained in the interviews, the The Hague portfolio is worth over 1 billion Euro. And beside the financial impact, the general view that real estate has significant impact on organisations is also present in government real estate: it has to be attractive and reachable to be an attractive employer in the *war on talent*. Sustainability is high on the political agenda and the government portfolio has to contribute to that. And prices are rising because of a growing shortage of buildings and land to build on.

In short: every bit of information that can contribute in decision making to make the supply versus demand process more effective and efficient is necessary.

Building based data is present in virtually all corporate real estate, in various levels of detail. This information is, at this moment, only used for the primary tasks the systems are implemented for: providing access, controlling HVAC, determine the bill for gas, water and energy usage. This data is like an untapped oil field. Information that is very much wanted by decision makers, especially occupancy rates, can be provided with this data. And this information has become even more relevant in the recent COVID-19 crisis, where real time statistics in occupancy have become a matter of public health. The question that could be asked: "is it worth the investment?" is probably answered by just this use case.

Big data strategies in public organisations are challenges, especially in implementation and upscaling. The amount of building based systems in the entire portfolio is significant. And the technical challenges are minor compared to organisational challenges in using big data. The data management project is a start for the CGREA. This project can help to focus which processes and data sources to focus on first. Providing occupancy data for offices to support strategic decision making can showcase the potential of a big data strategy. One of the greatest challenges identified -adoption by the decision makers- seems to be overcome simply by the fact that these decision makers are asking for these insights.

One final finding is not directly connected to the project, but can be concluded based on the interviews. The real estate strategy is never cited as the primary challenge or demand for information. Even though there are goals that have to be met with real estate, the challenges identified are primarily based on the primary goal: matching demand and supply. This is confirmed in literature, where public real estate is said to have only marginally started to adopt strategies with measurable KPI's. But in this case, the KPI

mentioned most frequent is financial viability. Sustainability, while a political spearhead, is not high on the list of challenges for the decision makers. This while building based data could provide statistics for possible KPI's related to, for example, energy efficiency and greenhouse gas emissions. Perhaps having KPI's that can be monitored by (building) data on a real-time dashboard helps strategy makers influence decision makers to adopt this strategy.

5.2 Discussion

This research focused on building based data for government real estate. Limitation in the time has resulted in a limited scope: only the office portfolio was targeted. This is only a subset in public real estate. And each portfolio has its own challenges. Because of a growing number of civil servants and the need to attract the greatest talents, offices have to be attractive and space has to be available. The locations that the offices of public organisations are usually located in, within large city centres near transport hubs, are expensive and short in supply. This means that the match between supply and demand is very important. And this also means a greater need for insight, in this case, in occupancy rates. The question is if the same information requirement is present in prisons (where a steady decline in inmates has fuelled the need to divest real estate) or the defence portfolio (where overdue maintenance is a main challenge). But the fact that occupancy was also mentioned in other public real estate owners strengthens the case to make this information available.

The second question is if it will really work in the political context. Insight in occupancy is mainly cited as a means to have a more objective discussion, to influence users and decision makers higher in the organisation. Will these actors be susceptible for these arguments and statistical data? Will a director of a government agency accept the CGREA explanation that "the building really is not full yet" and tell his or her complaining employees to stand down?

And finally, big data in government organisations is not as of yet a very successful endeavour, as seen in the literature. While the usefulness for this data is there, according to this research, there are many actions needed to be able to use it for the entire portfolio. An important question is if the CGREA meets the requirements for successful implementation of a big data strategy.

5.3 Future research

The main focus for this research is on Dutch government real estate. The organisations that are responsible for public real estate are very different in various countries (Kaganova & Amoils, 2020; van der Schaaf, 2002). This makes it difficult to compare, for example, challenges and goals. Therefore the focus is on Dutch government real estate, where organisations are comparable because various government organisations adopt the same organisation structure. For future research, the applicability of the conclusions of this project for international public real estate organisations is a possible topic.

This also accounts for the part of the portfolio used. The CGREA has, as described, a varied portfolio. Different types of buildings come with different challenges for real estate management. Because of the multiple housing systems, the decisions made and the amount of control the CGREA has over strategic decisions, is also different. This research focuses therefore on the part of the portfolio that the CGREA has most influence in: the office portfolio. Future research could focus on other types of buildings with other usage scenarios, for example prisons or defence installations.

Also, important relevant topics related to using building based data (or any other type of data for that matter) such as privacy and cybersecurity (as defined in Section 2.1.3) implications are extensive enough to warrant a research project in itself. Therefore, those were not explored in this project but make an interesting topic for other researchers.

The final topic is the decision making level. Decisions are made on various levels of real estate organisations: strategic, tactical and operational. In all of these levels, information is used. This project focuses solely on the strategic level of real estate management: buying, divesting, building and transforming real estate. Usability of data on other levels of decision making is subject to further research.

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